THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
James H. McGraw, Pres.; Curtis E. Whittlesey, Sec. and Treas.

MAIN OFFICES:
239 WEST 39TH STREET, NEW YORK.

BRANCH OFFICES:
CHICAGO: Old Colony Building.
PHILADELPHIA: Real Estate Trust Building.
CLEVELAND: Schofield Building.
SAN FRANCISCO: Atlas Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Cuba and Mexico............$3.00 a year
Canada ....$4.50 a year
Foreign subscription......................$6.00 a year
25 shillings. 25 marks. 31 francs.

Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGES OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to July, 1906, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. The rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1907, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 14,250 *copies are printed. Total circulation for* 1907 *to date* 552,250 *copies, an average of* 14,533 *copies per week.*

TABLE OF LEADING ARTICLES.

The Calumet Canal.............................. 303
Another Lesson on Signals.............................. 303
The Protection of Trade Secrets.............................. 304
The Improvement in the Railroad Situation........ 304
The Selby Hill Street Railway Tunnel, St. Paul, Minn. (Illustrated) 306
The Electric Elevator Equipment for a Tall Office Building. (Illustrated) 309
Factory Lighting.............................. 310
A Concrete Power-Plant Reservoir. (Illustrated)... 312
Electricity for Cement Plants.............................. 313
The Hydro-Electric Plant of the McCall Ferry Power Co. (Illustrated) 315
Cost-Keeping as an Aid in Managing Men.......... 321
The Suspended Falsework of the Cantilever Arms of the Quebec Bridge. (Illustrated)............. 323
The Cooling Plant for Walter Baker & Co., Ltd., Dorchester, Mass. (Illustrated)................. 325
A Convenient Profile Chart and Map. (Illustrated). 327
Inspection of Asphalt Paving in the Borough of Manhattan, New York City.............................. 327
Test of the Reinforced Concrete Viaduct of the Richmond & Chesapeake Bay Ry. (Illustrated)....... 328
Book Notes 329
The Union Pacific Location.............................. 330
The Quebec Bridge Collapse.............................. 330

The Calumet Canal.

The Chicago Real Estate Board has been looking into the project of the Trustees of the Chicago Sanitary District to construct a canal for the disposal by dilution of the sewage of the Calumet district, and its committee appointed to investigate the subject has protested vigorously against the proposition to construct such a branch of the present drainage canal. This Calumet canal is proposed by the Sanitary District trustees on the ground that it is needed to care for the sewage of the district about the Calumet river, that it will furnish a navigable waterway, and that its construction will enable a large water-power to be developed. It is pointed out that these triple aims complicate the problem, originally a purely sanitary one, and do not provide any further improvement of the Chicago river which, in view of the money already spent on the drainage works by Chicago taxpayers, might be considered of considerable weight. Some astonishing figures to show the importance of an immediate betterment of the river are given in the committee's report on the authority of Colonel Bixby. It is stated that in 1889 the tonnage entering the Chicago river was over 9,000,000 tons while in 1905 the tonnage entering both the Chicago and Calumet harbors was only 7,000,000 tons, excluding the shipments of iron ore which did not amount to much on the earlier date. During the same period the tonnage entering Duluth harbor increased from 3,000,000 to 22,000,000 tons, including about 7,000,000 tons of miscellaneous freight during 1905. The tonnage entering Milwaukee harbor in 1905 was at least fifty per cent. more than that of 1893. These figures are asserted by the Real Estate Board to indicate that the interests of the Chicago river as a harbor cannot be neglected upon the supposition that what is lost to the river will be gained through the Calumet; it is claimed, in other words, that so far as any navigation advantages resulting from drainage canal work are concerned it would be far better to concentrate attention on the Chicago river.

Turning from the navigation to the power aspect of the projected Calumet canal, the same arguments are advanced. The Real Estate Board claims that the argument for spending $13,000,000 for the new canal in order to develop power which can be sold for enough to pay interest on the cost of the work, is really as good an argument for obtaining the same amount of power by enlarging the Chicago river. It is true that the cost of the latter work is estimated at $20,000,000, but the additional expense is well worth while on account of the improved navigation facilities afforded, according to the report of the committee. Another aspect of the matter is also brought out in a letter to the committee by Mr. John W. Alvord. "It is a little difficult to see how this project," he writes, "which looks on the face of it to be purely for commercial purposes, can be related to the sanitary problems of Chicago, for which the district was created; and when one considers the risks and disappointments attending a business enterprise of this sort, it seems to be an open question if it is desirable for a public board to commit a municipal corporation like Chicago to a purely business enterprise, which is admittedly entirely unnecessary for the sanitary betterment of this community."

So far as the sanitary aspect of the problem is concerned, attention may be called to the report on the Calumet sewage disposal problem made by Messrs. Hering and Fuller some time ago to the International Waterways Commission and reviewed at considerable length in this journal on February 2 of the current year. In this report it was shown that for the Calumet district there are several methods of sewage disposal as effective as the method of dilution in preventing the pollution of the lake water, the most advantageous one being the use of septic tanks and sprinkling filters. This report is much more encouraging than a good many people in Chicago probably realize. It means that when the capacity of the present drainage canal as a receptacle for sewage has been reached, other methods of disposing of the surplus sewage are available, and if Chicago continues to grow as she has in the past the time is not so far distant when the modern methods must be adopted. It seems hardly conceivable that all the great cities depending in a large measure on their harbors for their prosperity will calmly allow Chicago to divert more water from Lake Michigan for sewage disposal purposes when that diversion means such a lowering of the level of the Great Lakes that navigation will suffer unless costly dredging is undertaken.

The continuation of this method of sewage disposal by Chicago seems likely to become wrapped up in a great project of a Lakes-to-Gulf waterway, and it is pertinent to inquire whether the advocates of this latter project have yet stated where the water for navigating the upper section of this great channel is to come from. If it is to be drawn from the Great Lakes it is surely in order to suggest that its effect on the American and Canadian harbors should be carefully investigated. The great commerce centering in them is an accomplished fact, a matter of pride to those engaged in it, and its injury for the purpose of enabling Chicago to dispose of sewage which can be otherwise handled, or to build a big power station, or to develop an inland waterway which is of problematical value, seems neither wise as a matter of transportation nor necessary as a sanitary measure. The deep waterway convention to be held in Memphis shortly will be well worth watching by the Great Lake cities on account of the facts just stated. The diversion of 10,000 cu. ft. of water per second by the present canal, which was permitted by the Deep Waterways Commission as a sort of moral obligation for not stopping the construction of the drainage canal at the outset, is stated by that Commission to be equivalent to a lowering of the lake levels from 4½ to 6½ in. The tremendous effect on lake commerce of any further lowering by a greater diversion of water is something to be regarded with apprehension.

Another Lesson on Signals.

Last week this journal made some comments on the dangers which lurk in current practice in railway signaling. Following it with frightful rapidity comes the news of another ghastly "accident" on a New England line in which more than sixty passengers were killed or hideously mangled. We all remember General Sherman's characterization of war, but the intentional slaughter of war is a Sunday School picnic in comparison with the awful details of such a tragedy as this. The soldier who follows the flag into the Valley of the Shadow has at least given his life for his country's welfare, but what consolation is it in the last bitter moment to him who is torn and crushed in the shattered wreckage of a train that he has helped to save the expense of a good signal system? In the case before us an express train, late and trying to make up time, met a heavy freight train in the gray mist of dawn in a headend collision. Probably somebody blundered, as is usual in such cases, a telegram went astray or was misread, and the usual result followed. If these collisions were an inevitable part of modern transportation, if they occurred impartially under every system of management and in every country, one might perhaps learn to take them philosophically and, thanking his lucky star for personal escape, go about his business without a protest.

It happens, however, that, as compared with other countries, our own has a sinister prominence in such calamities. The sanguinary casualty list of American railroads rises to near a hundred thousand victims annually. It is probable that accidents will never be entirely averted, yet comparison with records abroad shows that they can be greatly reduced in frequency by proper and usual precautions. There should certainly be means independent of mere telegraphic notice to prevent two trains from meeting on a single track, either in a head or rear end collision. The morning mists in the valleys of northern New

England are not new phenomena taking the unhappy railway men unaware. They are of regular occurrence before a clear autumn day and a known source of danger. They make the regular visual signals of no effect and prevent the trainmen from looking far enough ahead to clear the ordinary danger space. There is no use in writing down the catastrophe as an act of Providence, for there is no Divine law that prohibits the installation of good signals. Rather it must be set down to the blindness of those who will not see and the negligence of those who hold the lives of others cheap when it comes to a matter of business. It is one more evidence of the frightful inefficiency of the methods of signaling and train-dispatching used upon far too many railroads. It is high time for reform and for the introduction of better appliances. It is certainly not impossible to gain a far greater degree of security than now. Whatever system is used it is imperative to employ signals that can be made clear over at least the dangerous space of the train and that cannot be rendered useless by so common a cause as an early morning mist.

The Improvement in the Railroad Situation.

For a year or more engineers have necessarily been impressed by the important influence of public sentiment on the condition of undertakings in which a large proportion of their profession is engaged. Civic pride determines in a large measure the character of municipal works; in a community marked by business strength and public spirit the engineering works are generally planned on a broad and liberal scale and the men entrusted with their execution have the respect and confidence of the public. On the other hand, in cities which are devoid of this civic good feeling, public works are neglected and engineering offices are looked upon simply as political prizes. The sentiment towards public service companies affects engineering in a still greater degree. These companies must operate under franchises and rights of one sort or another granted by state or city legislation, and the feeling of the public toward them manifestly affects the character of the privileges they will obtain. Moreover, public service corporations are still more vitally influenced by the effect of public sentiment on the prices of the securities of such corporations. The great works these companies carry out must be constructed by private capital, and without reasonable security in investments of this nature, people are naturally loath to lend money for such undertakings. The extent to which these considerations influence the engineering profession can be readily understood by an examination of the lists of members of the four national engineering societies; it will be seen that an extraordinary percentage of the members are engaged in enterprises directly affected by public sentiment or in the manufacture of supplies for such works. Under such circumstances it is self-evident that the engineer should study these problems of the relation between the public and public-service companies from a purely selfish point of view as well as on account of his obligations as a citizen of a democracy. The hysterical waves of public antipathy toward all companies engaged in public-service work are unfortunate from every point of view.

It is encouraging to observe how the hostile spirit shown toward railroads and in a somewhat less degree toward street railways during the last two years is now subsiding. There was a time not so very long ago when the railroad official who held any feeling of regard toward the public except as a source of revenue was hard to find. After a street railway or electric lighting company received its charter and franchise it generally assumed toward the public an attitude which indicated its belief that it was engaged in business in exactly the same way as a commercial corporation conducts a department store. The fact that it was operated by public permission in a distinctly public service, affecting the methods of business management which it could rightfully follow, seemed for many years to be overlooked. When the public became dissatisfied with the service rendered, the possibilities of retaliation which the people possessed were overlooked or under-estimated by the companies' officials. The experience of the last two years, particularly the last winter, has shown that the public control of such companies is sufficiently great to thwart methods of management that persistently ignore public rights. From one end of the country to the other it is now recognized by all far-sighted men that the time has gone by when the capitalization of a public service corporation may be safely based upon anything but the cost of constructing the works and meeting the expenses incidental to the beginning of regular efficient service. The day of capitalization based upon maximum earning capacity has gone by.

In an interesting address at the fourth annual meeting of the Association of Transportation and Accounting Offices, Mr. A. G. Briggs, general attorney of the Chicago Great Western Railway, made the following statement: "The railroad company was organized upon the agreement that the stockholders might build, equip and operate the railroad, furnish proper service to the public and charge for that service a reasonable compensation; but always with the reservation, clearly understood, that should the stockholders fail to render proper services or should they charge more than a reasonable compensation for them, the state might, at its option, assert its right to regulate or control the railroads, determine what service should be rendered, how it should be rendered, the terms on which the road should be operated and for what compensation. This reserved right is absolute, limited only by the rule that the state cannot confiscate the stockholders' property or deprive them of a reasonable return on their investment." It is particularly instructive to notice that Mr. Briggs, speaking as a railway man to railway men, refused to consider the recent legislation against railroads and other public-service corporations as the work of demagogues. With some few exceptions, in his opinion, those responsible for these laws did their duty as they saw it. He believed the great majority of officials and legislators have tried to learn and do what is right, and the legislation they passed was due in no small measure to a general public opinion that no reliance could be placed on statements by public-service corporations. Unconscious prejudice is a potent factor in influencing legislation, and the measures of last winter are to be accounted for by it rather than by evil motive. He believed that the wave of public distrust had passed early in the summer, and that it was the duty of everyone connected with public-service corporations to win back confidence in the intention of such companies to render efficient service.

The other side of this matter was stated at some length at the meeting of the American Association of Freight Traffic Officers on September 14, by Mr. Martin Knapp, chairman of the Interstate Commerce Commission. His long connection with that Commission lends particular weight to the opinion, stated emphatically, that the Sherman anti-trust law defeats the purpose for which it was passed, and if it were not violated by the railroads we should have a chaotic condition suited only for savagery. This is an acknowledgment of the necessity of improved legislation deserving careful attention. Mr. Briggs told the railroad men he addressed that the greater good of railroads is in maintaining government inviolate, rather than in escaping temporarily the effects of a single valid law or of several such laws. It was his opinion that whether a law was bad or good the railroads should abide by it until it was repealed or amended. Mr. Knapp, speaking as the public official most directly concerned with enforcing national legislation concerning railroads, stated that the anti-trust law might have been applicable in the old days of stage coaches but was unsuited for present conditions. With railroad men like Mr. Briggs urging obedience to the laws and attention to reasonable public wishes, and officials like Mr. Knapp urging the passage of laws which will be helpful rather than harmful, it seems reasonable to anticipate that before long a more complete appreciation of the necessities and methods of control of public-service corporations will result in more equitable legislation, better service and less public distrust of such companies.

The Protection of Trade Secrets.

The protection of trade secrets was the subject of an important address by Mr. F. P. Fish before the American Society of Mechanical Engineers some months ago and since then several courts have decided cases of this sort. There is one feature of the matter, however, which has only recently been discussed judicially, although it is something that must have frequently been considered by manufacturers. This is the extent of the protection which will be afforded to a company employing a secret process not devised by anybody connected with it and obtained from another source than the original inventor. A case of this nature has recently been passed upon by the New Jersey Court of Errors and Appeals in the Vulcan Detinning Co. v. American Can Co. et al., 67 Atl. Rep., 339. The facts in this case are substantially as follows, according to the statements made by the court. Until about ten years ago the detinning of scrap had not been carried on successfully in this country although such a process was successfully operated abroad. This fact was well known to the dealers in tin scrap who had a large trade with a Flushing establishment as well as with one in Essen. In 1898 a number of American dealers and manufacturers agreed to build a plant for detinning scrap in this country providing a license for using the foreign method was obtained. In order to secure this license Adolph Kern, a dealer in scrap tin, was sent to Europe and obtained the secret from the Flushing company with permission to install it in two plants in the United States. These plants have passed into the possession of the Vulcan Detinning Co., the complainant in this case. The process was discovered by Goldschmidt Bros. and used by them in 1891 in Essen, where it was guarded as a secret. The same process was used at Flushing, where it was also kept a secret, although it had been obtained from the Goldschmidt works clandestinely. The Americans who obtained the secret from the Flushing establishment guarded it zealously. F. A. Assmann, one of the original promoters of the complainant company, was so impressed with the importance of guarding the process that he himself became individually the trustee of a copy of the formula for the express purpose of guarding it for the mutual benefit of himself and his associates. The business was a commercial and practical success from the outset. In 1901 Assmann transferred his personal interest as a manufacturer of tin cans to the American Can Co., the defendant in this case. He became its president and sold to it all of his holdings of stock in the two detinning companies, resigning his directorship in each. He also was the leading spirit in the installation for the American Can Co. of two detinning plants using the process employed by the complainant, and called to his assistance three former employees of the complainant.

The testimony in the case, according to the decision rendered by the court, admits of no other conclusion than that the detinning plants which came into existence in this way in competition with those of the complainant, are employing the process originally purchased by the complainant which Assmann undertook to safeguard in its interest. That this result was brought about by a breach of confidence upon his part toward his original associates, both as regards the use of the process itself and the enticement of the former employees of the complainant, is stated by the court to be the only legitimate inference that can be drawn from the proofs. That in both of these respects he was acting directly on behalf of the defendant corporation of which he was president is decided to follow as a necessary deduction. The result of such conclusions is to raise the question whether upon such facts the complainant is entitled to any relief, and if so, to what extent.

The defendant's counsel argued that the complainant was entitled to no relief because the secret process it sought to enjoin the defendant from using was not, in fact, a secret, and moreover if it was a secret, the legal title to it did not exist in the complainant. From what has been said concerning the source of the secret, and the organization of the various companies in this country using it, it will be seen that the case is unusually complicated. The court discusses it at considerable length and the various considerations it mentions are of such a strictly legal nature that it is hardly necessary to follow them at length in this place. The conclusion to which they lead is that, entirely aside from the technical secrecy of the process or the abstract question of property in it, the complainant company is entitled to have its former trustee, Assmann, his associates and their servants restrained from using against the interest of the complainant the very process with which Assmann was entrusted for its benefit. The court points out that, apart from the peculiar rights of its discoverer, the secrecy of a process may be viewed in two aspects; first, as having for its object the keeping of the public in ignorance of the nature, source or composition of a commercial product that is put upon the market, and second, as having for its object the prevention of competition by rivals in production. In this case the publication by Assmann of the secret would violate the obligation of secrecy in each of these respects, but, as regards the second, the trust is held to be equally violated if the trustee himself uses the secret to engage in such competition, even though, as would clearly in this case be to his interest, he sedulously keeps the secret to himself, excepting so far as his use of it requires the cooperation of associates and servants. The court decides that when Assmann severed his connection with the complainant and installed the process in question for the defendant corporation as a competitor in production, it is the same in equity as if, without having severed such prior connection, he had broken faith with his fellows by imparting to a rival the secret which he had promised to preserve.

Although the court considers that there is no question about this action by Assmann himself, there is some question concerning the relief the complainant should receive against the defendant corporation for which Assmann was acting when he did the acts that constituted his breach of trust. It is all but impossible, the court says, to avoid the conclusion that the directors of the American Can Co. had actual knowledge of sufficient facts to constitute notice that Assmann held the secret of the complainant's process in a confidential capacity. On the other hand it is all but impossible to demonstrate by direct proof that a corporation has knowledge apart from the knowledge possessed by agencies through which its functions are performed. Hence in such a case the mere fact that the complainant is unable to adduce any corporate resolution of the defendant company expressly asserting its knowledge of the complainant's secret and of Assmann's connection with it does not prevent the court from reaching the conclusion that the defendant had such knowledge, if such is the inference to which the testimony tends by irresistible weight of probability. This consideration brings up another intricate point which the court argues at considerable length before reaching its final conclusion, which is that the defendant corporation is amenable to the same degree touching competition and publication as that already accorded to the complainant with respect to Assmann individually. The court therefore orders a verdict to be found restraining the defendant Assmann and the American Can Co. from using or making public this detinning process.

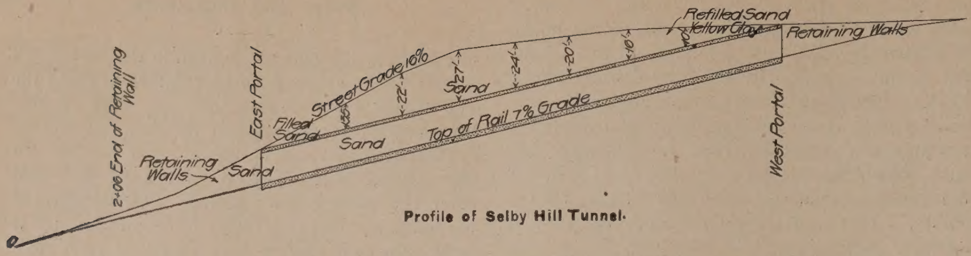
There is one further complication of the case that must be mentioned. There can be no question that Adolph Kern knew of the fact that the process used at Flushing was the same as that employed by the Goldschmidts at Essen and was obtained surreptitiously from them. It was held in one of the lower courts where the case was tried that this knowledge on the part of Kern, who became an agent of the incorporators of the complainant company, must also be imputed to that company, which therefore came into the court with "unclean hands." The Court of Appeals points out that there is a nice distinction in this matter. That the knowledge possessed by an agent but not acquired by him while acting for his principal will, under certain conditions, be imputed to the latter, is in the nature of a presumption indulged in by courts in working out the rights of litigating parties. The Court of Appeals points out that it is never a rule of evidence by which the actual possession of knowledge by the principal can, in point of fact, be established. On the contrary an essential part of the presumption in question is that the principal is ignorant of the knowledge that has been casually acquired by his agent. Hence, by the hypothesis, the principal is not only ignorant of the knowledge thus acquired, but, if such knowledge involves a fraud, the principal is innocent of such fraud. He may be bound by it in the sense that his legal rights may be determined with reference to the knowledge with which he is thus chargeable, but his conscience is void of offense, and hence it cannot be said with propriety that his hands are unclean, for "unclean hands" within the meaning of the maxim of equity that "one who comes into equity must come with clean hands" is a figurative description of a class of suitors to whom a court of equity as a court of conscience will not even listen, because the conduct of such suitors is itself morally reprehensible as to known facts.

Taking the case as a whole, it seems to be one of those which deserve a careful consideration by members of the engineering profession who have to do with inventions and their commercial use. As Mr. Fish pointed out in his address to which reference has already been made, the practice is growing of relying upon trade secrets rather than patents in certain kind of manufacturing. Cases involving trade secrets are bound to come up more frequently in engineering work and it consequently behooves engineers to keep in touch with the legal opinions concerning such matters. On the facts as presented in the opinion of the Court of Errors and Appeals, there can be no question that the decision just reviewed is in accord with principles of equity, particularly in view of the fact that the original inventor of the secret process had refused to take part in establishing a factory in America on the ground that it would be commercially impracticable.

Notes and Comments.

Publicity is again being given in the New York papers to the attempts of speculators to force the Board of Water Supply of New York to pay unnecessarily large sums for land needed in connection with the new Catskill water works. In this connection it might be pointed out that soon after the work in the Catskills was inaugurated the property owners likely to be affected by it were informed that if they cared to rely upon the Board of Water Supply and its representatives for fair treatment they would probably receive far better returns for any of their property needed for the works than they were likely to obtain by any other course. Events indicate that this is true. Those property owners who did not give up title to their land will receive from the commissioners the same sum for the same class of land as the speculators will get who bought property for a much lower price from the original holders. It is very unfortunate that this unwillingness to rely on the fairness of the commission has existed along the line of the new works, but those who have held it must thank themselves alone for the unfortunate results of their poor judgment.

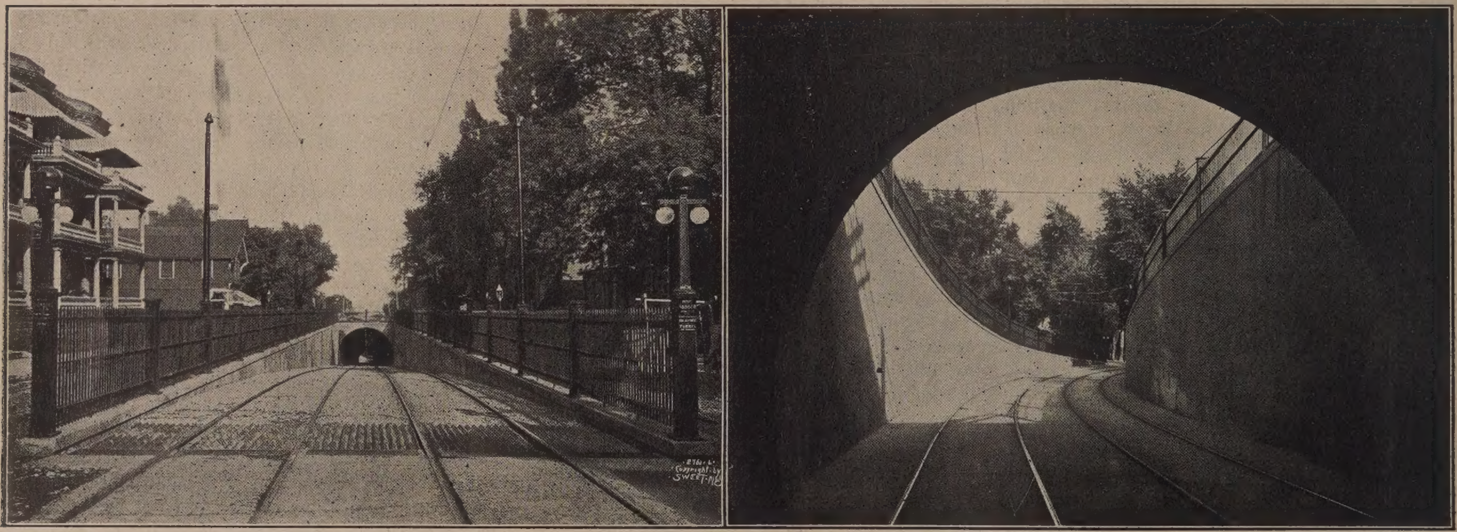
The Battery Tunnel connecting the lower end of Manhattan with Brooklyn is rapidly approaching completion, but not rapidly enough to satisfy many people who wish to use it. Consequently there is a good deal of newspaper criticism of the work which is likely to cause some misapprehension concerning it. The tunnel is a part of a contract awarded by the late Rapid Transit Railroad Commission to the Rapid Transit Subway Construction Co., a subsidiary company of the Interborough Rapid Transit Co. operating the subway. The Construction Company has until May, 1908, to complete the entire contract. It is to its interest to get the work done as rapidly as possible in order that the Interborough train service may be started. It sublet the work in three sections. That in Manhattan has been finished and in operation for a considerable time. That in Brooklyn is well on toward completion although extensive modifications of the plans have delayed it. The tunnel under the East River is almost finished. It presented a number of new engineering problems and, like most subaqueous tunneling, developed difficulties which could not be foreseen. Concrete piles driven under the tubes where they cross fine sand have been carried down 75 ft. in places by the contractors in order to provide an additional safeguard, although Mr. George S. Rice, the chief engineer for the Commission, considered them unnecessary. The tubes have been reconstructed wherever the subcontractor deviated too much from grade, and there is now the same clearance for the cars in these tubes that has been provided in other parts of the subway. The same people who are the general contractors for the work will also have to operate the trains through the tunnel, as before stated, and consequently they have spared no expense to secure substantial and proper work. Unless something now unforeseen arises, which is always possible before the final completion of any subaqueous tunnel, trains will be running before the end of the contract time. Mr. Rice stated recently that cars might be started in one of the tubes in October although this was more likely to take place later, probably some time in November. In view of all the difficulties and new problems that have been encountered, this will be a surprisingly good showing. If new difficulties arise it is to be hoped that the Public Service Commission will disregard any clamor based on ignorance of these difficulties and will take a firm stand for the completion of the work in the best possible manner before authorizing trains to be put in service.



Profile of Selby Hill Tunnel.

THE SELBY HILL STREET RAILWAY TUNNEL, ST. PAUL, MINN.

The Twin City Rapid Transit Co., of St. Paul and Minneapolis, has recently completed and placed in service a subway tunnel which greatly reduces a steep grade on one of the most important street railway lines in St. Paul, and eliminates the necessity of a counterweight formerly used to handle cars up and down this grade. The new tunnel is on Selby Ave., a short distance from the business district of the city. At the location of the tunnel the grade of the street was 16.5 per cent. for several hundred feet, the business district being 125 to 150 ft. lower than the residence sections at the top of this hill. The cars of one of the three interurban lines between Minneapolis and St. Paul, as well as local cars, were operated over this steep grade, on which the counterweight device had been used since electric traction was substituted in 1898 for the existing cable line on this street. The counterweight device consisted essentially of a traveling cable and a counterweight in a conduit below the street surface, and two grip cars, which were used to haul the street railway cars up and down the steep grade. The number of cars passing over this line became so great that the counterweight could not handle them fast enough to avoid delays. In order to eliminate the delays due to the auxiliary apparatus, and to obtain other operating advantages, the decision was made to build a double-track tunnel from the base of the hill to a point far enough back on Selby Ave. at the high level to obtain a satisfactory grade.



Approach to Upper End and Exit from Lower End of the Selby Hill Tunnel at St. Paul.

The total length of the improvement required in the grade reduction is 1,700 ft., including the tunnel and the approaches. An approach, 230 ft. long, leads up to the portal of the tunnel at the bottom of the hill. The tunnel is 920 ft. long between portals and has an approach 320 ft. in length at the upper end. The lower approach is on a curve with a 500-ft. radius, but otherwise the alignment of the improvement is straight. The grade of the new track is uniformly 7 per cent., as compared with 16.5 per cent. on the old track. The approaches are so arranged that after the backfilling has all been placed, the street will again be opened for traffic at practically the original grades.

The approaches are between reinforced-concrete retaining walls, which vary from 3 ft. to a maximum of 20.5 ft. in height. Where these walls are less than 6 ft. high they are built as gravity-section structures. Above that height they are vertical, reinforced-concrete slabs, having a horizontal slab footing, and buttresses, 2 ft. wide and 6 ft. apart on centers, on the rear side. The approach to the lower portal of the tunnel is at one side of the street, a roadway parallel with it connecting with the street over the tunnel. The approach to the other end of the tunnel is at the middle of the street, but a 13-ft. drive was obtained on each side of it, so, on the whole, the street is much improved for highway traffic as compared with the old arrangement. The tops of the walls of the approaches and the portals of the tunnel are 0.5 ft. above the street grade, and are surmounted by a 6-ft. ornamental-iron picket fence, in order to prevent accidents.

The tunnel has a double-centered arch, with a span of 23 ft. at the springing line and a rise of 11.5 ft. The clearance at the center line of both tracks is 14.5 ft., while the center height is 16 ft. 10 in. The arch is 24 in. thick at the crown, and the bench walls are 4 ft. thick. Unlike most tunnels of this type that have been built the invert is perfectly flat, having a thickness of 2 ft., exclusive of the concrete in which the track structure is imbedded. The tunnel section proper required 9.782 cu. yd. of concrete per linear foot.

The concrete in the invert, in the side walls of tunnel up to the skewbacks of the arch and in the retaining walls was mixed in the proportions of 1:3:5. That in the arch was made in the proportions of 1:2:4. Owl cement, sand and run-of-the-crusher stone, with no pieces exceeding 2 in. in the extreme dimensions, were used in the 1:3:5 mixture; the stone in the arch was screened, pieces which would pass a 1½-in. ring and be retained on a screen with ¾-in. meshes being used. In all 10,400 cu. yd. of concrete and 55,000 bbl. of cement were required.

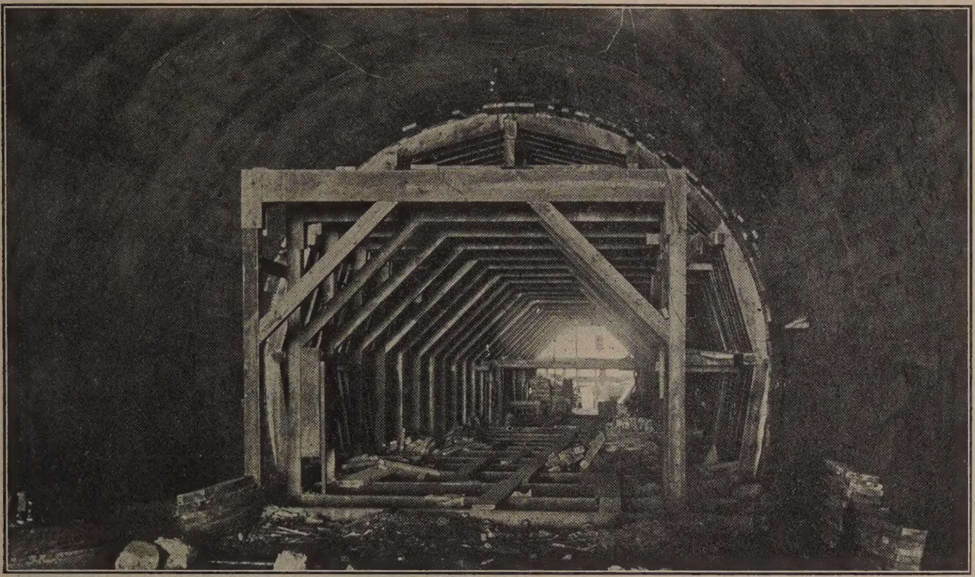
The details of the reinforcement of the tunnel section are shown in an accompanying illustration. The arch has two sets of 1⅛-in. round rods, alternating with girder rails, all of which are spaced as shown. The rods in the side walls have their lower ends imbedded in the invert, and extend up into the arch, overlapping those in the latter in such manner as to produce continuous reinforcement. The invert is reinforced with two layers of old rails, placed transversely. The rails in the lower layer are 28.5 ft. long and are placed 4 ft. apart on centers; those in the upper layer are 28 ft. long and are 12 in. apart on centers, their tops being 1 in. below the surface of the invert section.

The tracks in the tunnel have 80-lb. T-rails attached to creosoted ties with screw spikes. The ties and rails are imbedded in concrete to within 1¼ in. of the top of the ball of the rail, the concrete being finished to a smooth surface to form the floor of the tunnel. The floor between the rails of each track is practically flat, transversely with the tunnel, and between the tracks is depressed only slightly toward the center line. Connections to a drain are made at intervals of 200 ft. in the tunnel so the floor can readily be flushed clean, thus avoiding any difficulty from dust, or odors from refuse that would collect in stone ballast. At the same time the track structure is believed to be of such design that the concrete in which it is embedded will not have to be diturbed for a long period.

A 15-in. sewer pipe was laid under the invert, along the center line of the tunnel, from the entrance of the upper approach to the lower end of the improvement. An opening covered with a grating is placed across the end of the upper approach to intercept storm water and divert it into this sewer. Similar openings at other points in the approaches and the tunnel provide inlets to the sewer for storm water and for water used in flushing. The ground water back of the tunnel and retaining walls is also drained into this sewer through 4-in. laterals, which are placed 20 ft. apart on both sides of the main drain.

A four-way duct for cables is imbedded in the concrete along each side of the tracks, manholes being provided on these ducts at both ends and at the middle of the tunnel. Connections between the trolley wires and the cables in the ducts are made through conduits imbedded in the tunnel arch. The tunnel is lighted by 32-candle power incandescent lamps, spaced 10 ft. apart along the center line of the arch. These lamps are also connected to the cables in the ducts through conduits buried in the tunnel arch.

The construction of the tunnel was handled entirely in an open cut, 34 ft. in width, the maximum depth of the cut being 52 ft., and the average about 30 ft. The hill through which the cut was made consists almost entirely of a coarse glacial sand, containing some boulders and small stone. As the sand was practically free from clay, it would flow easily when dry. When the street was originally graded it was cut down 15 to 25 ft. below the natural surface on one side for a distance of 250 ft., toward the lower portal of the tunnel. A heavy masonry retaining wall had been built along that side of the street to hold back the ground, which continues to rise until a surcharge of from 10 to 30 ft. over the wall is produced within a short distance back from the street.



Forms and Centering for the Tunnel.

The deepest cutting for the tunnel was required along this wall, the top of the latter being 30 to 60 ft. above the bottom of the cut, while its base was directly at the edge of the cut. The work was successfully completed under these difficult conditions, however, practically no movement of the wall, or of the high bank back of it having occurred.

The excavation was started at both approaches and carried toward the middle. The material removed from the excavation was hauled away in 6-yd. dump cars handled by a motor-driven work car, until the amount removed was approximately equal to the quantity which had to be wasted. Most of this material was taken out of the approaches and was loaded into the dump cars by hand. Some of it, however, was taken from the tunnel cut, and a part of it was loaded into wagons by cableways.

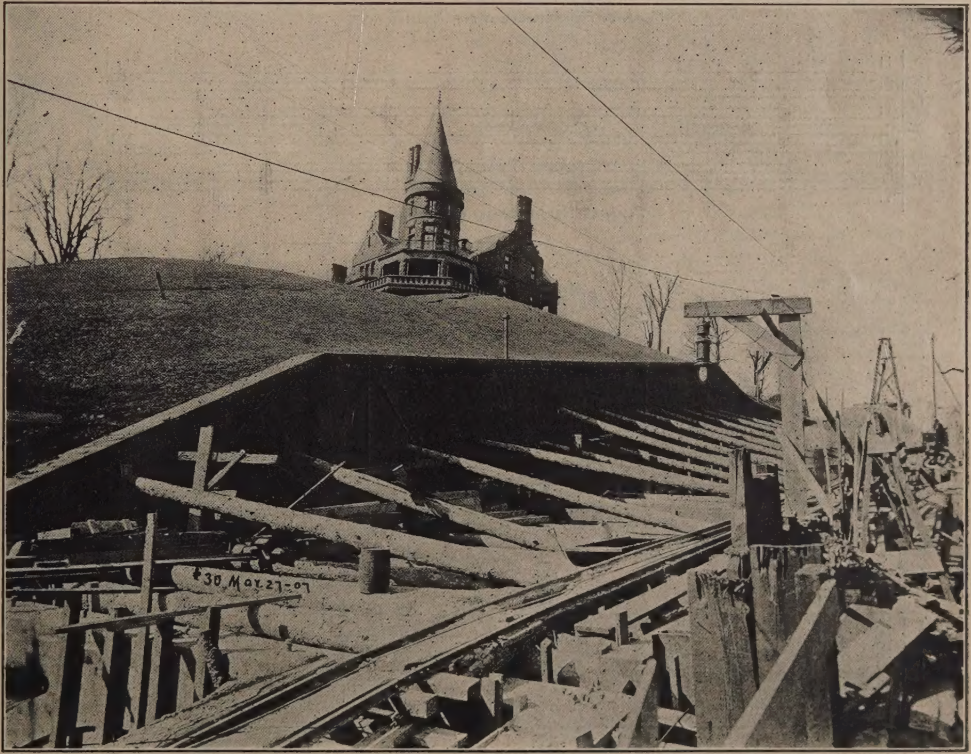
Two cableways each having a span of 500 ft., were set up over the longitudinal center line of the tunnel. The two head towers of these cableways were close together near the middle of the tunnel, one tail tower being just beyond the portal at one end and the other beyond the other portal. After the excavation for the approaches had been made and the retaining walls of the approaches had been built, the excavation and concrete work on the tunnel were handled so material removed from the cut at one point could be placed by the cableways as backfilling on a completed section of the tunnel, or could be stored in convenient piles, from which it would afterward be readily available for backfilling. As the excavation in the portion of the work spanned by the cableway at the upper end of the tunnel was considerably lighter than in the part spanned by the other cableway this portion was completed first. The cableway at that end was then placed on the same towers with the other cableway, after which the two worked in conjunction. Buckets with a capacity of 21 cu. ft. each were used in connection with the cableways, which handled nearly 50,000 cu. yd. of material during the progress of the work.

The cut had to be closely sheeted and heavily shored from end to end, owing to the nature of the sand through which it was made, and the necessity of protecting the adjacent property. The sheeting consisted of 4x6-in. timbers in 22 and 26-ft. lengths. Against this sheeting were placed horizontally 12x12-in. waling, or ledger timbers, spaced 6 ft. apart on centers. The waling timbers in the corresponding rows were braced across the cut by poles, 10 to 14 in. in diameter, and 35 ft. long. The cross braces were spaced 6 ft. apart along the waling timbers, thus making a brace at each corner of every 6-ft. square on the side of the cut. The sheeting was driven by hand in advance of the excavation, to a depth of from 8 to 26 ft., and when the excavation had reached that depth, a second set of sheeting was started inside the lowest waling timber for the first set, and was driven to the bottom of the cut. The bracing timbers were wedged in place as the excavation was made, light vertical braces being nailed to them near the middle to prevent sagging.

The 6x6-in. sheeting was replaced for 250 ft. along the base of the high retaining wall by heavy round piles, 26 to 46 ft. long, which were driven closely together. Since the edge of the cut had to be made close to the base of the wall these piles were driven within 18 in. of the latter. As the excavation was made in this section of the trench the row of piles were braced against the sheeting on the opposite side with the regular heavy poles. Inclined braces, with one end against the sheeting on the opposite side of the trench, were also placed against the wall at various points. After the sheeting and bracing had been built up in this manner, the braces being placed as the excavation was made, the tunnel was built and the backfilling placed on it without injuring the high retaining wall or adjacent property in any way.

In all, approximately 1,000,000 ft., board measure, of timber was required in sheeting and shoring the tunnel. Practically all of this was handled by the cableways, which greatly facilitated the speed with which the heavy braces and timbers could be delivered and placed.

The great pressures brought on the sides of the cut by the loose sand precluded any possibility of removing the bracing or sheeting as the concrete work progressed, without the load on each brace being transferred to another support capable of carrying this load. A system for building the tunnel section was developed, however, which not only provided for the transfer of the loading on the temporary braces, but also greatly simplified the centering for the tunnel arch. As soon as a section of the excavation was made ready for the concrete, the invert of the



Bracing against High Retaining Wall during Construction.

tunnel was laid nearly to the tops of the upper layer of reinforcement rails in it. Heavy concrete posts 4 x 4 ft. in cross-section, and reinforced with old steel rails, were built against the sheeting on both sides of the trench at the same time the concrete was placed in the invert. These posts were placed between the vertical rows of temporary braces and were 6 ft. apart on centers, a section of the two lower 12x12-in. waling timbers, 4 ft. long, being embedded in each of the posts. The posts were cast in rough plank forms, and were built enough in advance of the first work on the side walls of the tunnel to permit them to set for several days. They were held at the bottom by the invert and at the top by a temporary timber cross brace between the two corresponding posts on opposite sides of the trench.

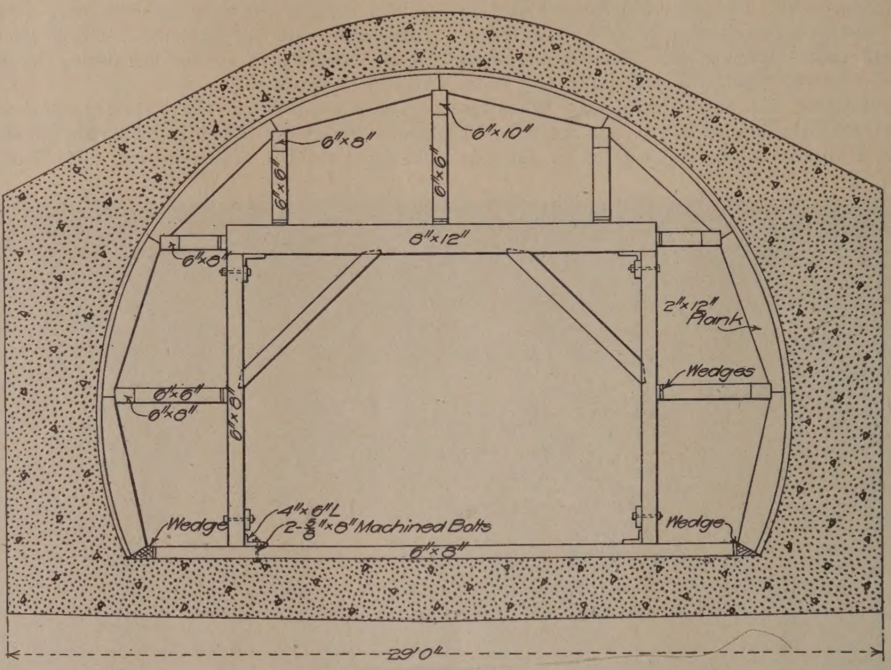
Timber bents were then erected on the invert in such position as to form a center for the forms of the walls and the arch of the tunnel. These bents were 12 ft. wide and 11 ft. high. They were built with a 6x8-in. sill, two 6x8-in. plumb posts and an 8x12-in. cross brace at the top. The bents were spaced 6 ft. apart on centers, being directly opposite the vertical 4x4-ft. concrete posts. When they had been erected as far as the side walls were to be built at that operation, the lowest row of temporary sheeting cross braces between them were removed one at a time, transferring the load on the bottom of the sheeting to the concrete posts. The inside forms for the walls up to the springing lines of the arch, 5 ft. above the invert, could then be set and braced at the top and bottom against the bents of the centering, the sheeting of the trench forming the outside forms. After these wall forms had been filled, enclosing the lower ends of the concrete posts, the concrete in them was allowed to set for a few days. The cross braces between the second row of walings from the bottom were then removed, the load on the sheeting carried by these braces being transferred to the concrete posts. The arch forms were next erected on the bents of the centering up to a height of 11 ft., or just under the third row of temporary cross braces, and the walls built up to that height. When this concrete had set, the third row from the bottom of the temporary cross braces between the sides of the sheeting, and also the temporary braces between the tops of the concrete posts, could be removed and the balance of the arch built.

In all this sequence of operations no part of the sheeting was at any time unsupported. At the same time, the centering and forms for the concrete were erected practically without interference and the concrete could readily be placed. The temporary braces were also all saved, although the waling timbers and sheeting had to be left in place, which would have been required in any case. On the other hand, comparatively little extra work, or extra concrete was required by extending the limits of the walls to permit the construction of the 4x4-ft. concrete posts which temporarily carried the load against the sheeting.

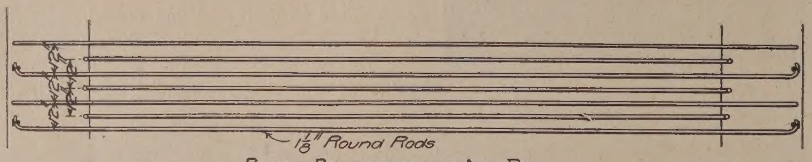
The forms for the tunnel had ribs made of 2x12-in. plank cut to a template to conform with the curve of the arch. These ribs were each in six sections, a section on each side extending up to the 5-ft. level of the walls, a second section on each side extending to the 11-ft. height, and two top sections in the closing part of the arch. They were spaced 2 ft. apart on centers and were lagged with 2x4-in. timbers. Ordinarily, the forms were permitted to remain in place at least 14 days before the centering was removed. The exposed surface of the concrete was all spaded carefully in the forms, with the result that a very uniformly good finish was secured.

Two concrete mixing plants, each containing a Smith mixer, were set up at the start of the work, one near each tunnel portal. The concrete materials were delivered to these plants by the work cars of the street railway company, over tracks which had been laid up to them. The concrete was handled from the mixers in 1-yd. Pettela narrow-gauge dump cars. For most of the work, two narrow-gauge tracks were laid longitudinally on the upper row of cross braces in the trench, one track toward each side of the latter. The cars from one mixer plant could be pushed along these tracks by hand, but at the other end of the work the tracks were on a grade, so the cars were handled by a hoisting engine set at the top of the grade. The concrete was dumped from the cars directly into place in the tunnel section.

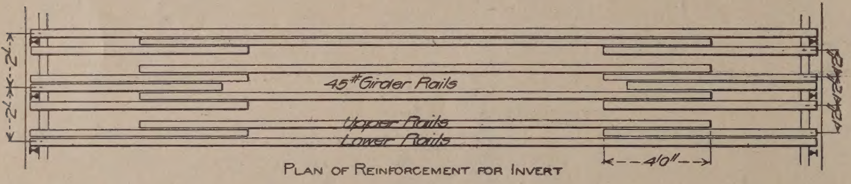
The concrete work on the tunnel was carried forward in sections of various lengths, depending on the manner in which the excavation could be prepared. Backfilling was not placed on the arch until the concrete was at least 10 days old. The material from the unfinished sections of the



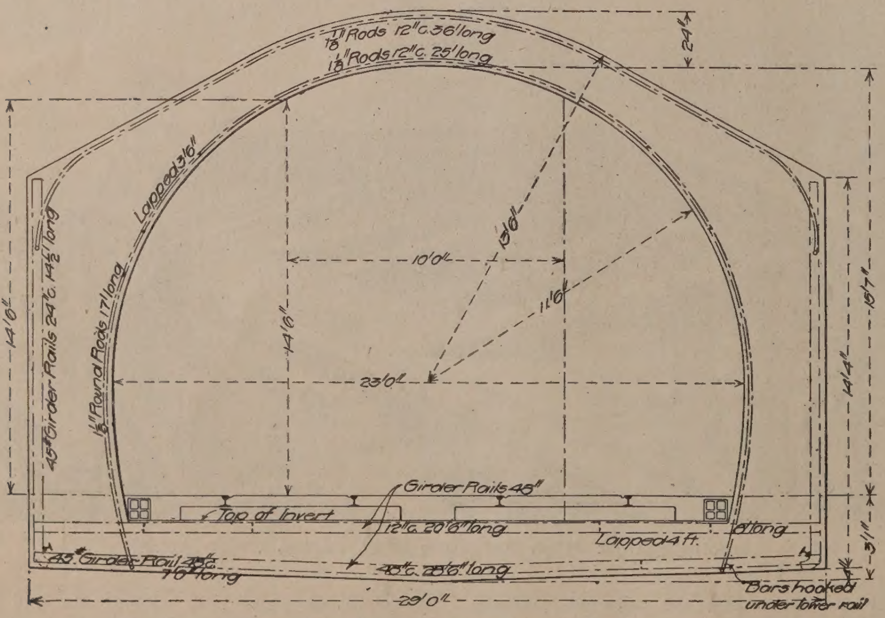
Centering and Forms Used in Constructing Tunnel.



Plan of Reinforcement for Arch Ring



Plan of Reinforcement for Invert


1 1/8" Rods 12" c. 36' long
1 1/8" Rods 12" c. 25' long
24"
Lapped 3'6"
45# Girder Rails 24" c. 14 1/2' long
1 1/8" Round Rods 17' long
14'6"
14'6"
10'0"
13'6"
11'6"
23'0"
14'4"
15'7"
Girder Rails 48"
Top of Invert
12" c. 20'6" long
Lapped 4 ft.
8' long
45# Girder Rail 48" c. 7'6" long
48" c. 28'6" long
3'1"
Bars hooked under lower rail
29'0"

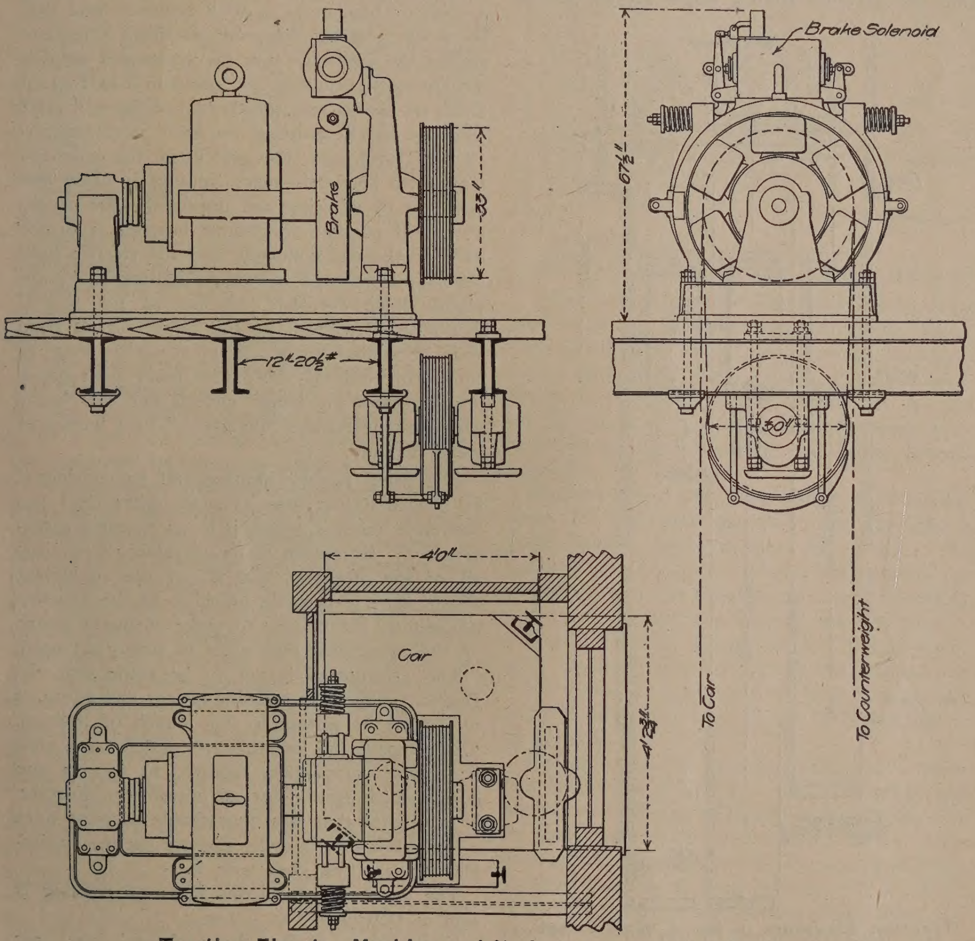
Transverse Cross Section of Tunnel Showing Reinforcement.

trench was generally piled on the finished concrete work by the cableways. The excavation was planned so very little of the material had to be handled twice, the backfilling being carried forward from both ends toward the middle of the tunnel. Approximately 4,000 cu. yd. of material had been stored on both sides of the trench in a street which crosses the tunnel about midway, and was used to close the final section. This stored material was entirely out of the path of the cableway, but was very economically handled back into the trench by a drag-scoop arrangement that was adopted. A double-drum hoisting engine was set up near the edge of the trench, close to the pile of material. A cable on one drum of this engine was rove through a block on the opposite side of the trench, and then carried back to the front end of the drag-scoop bucket, which had a capacity of 1½ cu. yd. Another cable on the second drum of the engine was rove through a second block on the opposite side of the trench, from which it was carried to a block in the rear of the pile of material and then to the back end of the bucket. The latter could thus be pulled back and forward from the storage pile to the trench very rapidly, discharging its load into the trench. Four men were required to operate the outfit; a driver for the hoisting engine, a signal man and two men to guide the scoop bucket as it was being filled. When the outfit was working to its full capacity it would handle as high as 250 cu. yd. in 10 hr.

The tunnel was designed by the engineering department of the Twin City Rapid Transit Co., of which Mr. George L. Wilson is engineer, and was built under the direction of that department by Mr. George J. Grant, general contractor of St. Paul. Mr. Charles R. Shepley was engineer in charge of the design and construction for the company. Prof. F. H. Constant, professor of structural engineering, University of Minnesota, assisted in the design.

The Electric Elevator Equipment for a Tall Office Building.

An 18-story office building has recently been completed at No. 1 Wall St., at the corner of Broadway, in New York City, which is a very unusual structure, occupying a ground plan approximately 30 x 40 ft. in size and rising to a total height of over 220 ft. above the sidewalk. It has the distinction of occupying a site for which a greater price was paid per square foot than has ever before been given for a building lot in New York City. Owing to the greatly restricted floor plan, an interesting feature is the interior arrangement of the building and the methods of communication between floors. As the available interior space on each floor averages but 28 x 37 ft., in which is included the elevator shafts and stairway enclosures, none of the floors are subdivided, each of those above the ground floor being devoted to a single large office, while the ground floor and basement are rented for store purposes, the basement communicating directly with the uptown platform of the Wall St. station of the Subway and serving as one of the station entrances. This interior arrangement obviates entirely the necessity of corridors on the upper floors and leaves the space that would otherwise be thus occupied available for office purposes, except on the ground floor, where an entrance corridor is necessary, and on the 18th floor, where there is a corridor for access to the upper works of the elevators. Stairway communication between floors is afforded by a line of stairs in a narrow enclosure at the rear corner of the building, having an inside measurement of 6 x 10½ ft.



Traction Elevator Machine and Its Location over Hatchway.

Three elevators have been installed in a shaft 17 ft. long by 5 ft. deep, at the rear of the building, which is enclosed by wire glass partitions throughout its height, the elevator doors opening directly into the offices on the various floors. Two of the cars are arranged to travel from the basement to the eighteenth floor, a rise of 217 ft., 1½ in., while the third travels from the first to the eighteenth floor, a rise of 200 ft. 3½ in. The elevator mechanisms are each designed for maximum capacities of 2,000 lb., the machines being capable of moving the cars at a maximum speed of 500 ft. per minute with loads up to 1,500 lb. The cars are, of course, owing to the limited space available, of comparatively small size, having outside dimensions of 47½ x 51 in. The hatchway doors at each floor are of the double-telescoping type, giving an unobstructed opening of 38 in.

Considerable interest is attached to this installation for the use of the Otis traction type of electric elevator machines, these being the first high-rise machines of this type that have been installed in New York City. This type employs a cable drive in its simplest form, entirely devoid of gearing, the elevator cables merely passing over a driving sheave which is mounted directly on the motor shaft, and are thus driven by the adhesion imposed by the weight of the car and counterbalance weights. The cables pass from the car over the driving sheave, thence for additional adhesion down under an idler sheave immediately below, and again up over the driving sheave, being attached at their other ends to the counterbalance weight. The speed of the car is thus always equal to the circumferential speed of the driving sheave. The motors are of a special slow-speed design, operated by the improved type of Otis magnetic control for rapid acceleration, and the two half wraps around the driving sheave give all the adhesion necessary for ordinary elevator service. The equipments are thus of the simplest possible form and specially adapted for high lifts and high speed, the height of lift being limited only by the practicable length of cable. This type of machine has, in fact, been adopted for the extreme high rise elevators in the 42-story section of the new Singer Building in New York City, and of the 45-story tower of the Metropolitan Life Insurance Building.

The elevator machines are, in this installation, located at the top of the elevator shafts in a pent house above the roof. This is, however, an arrangement to which this machine is particularly adapted and is an advantageous one, the machines being so located over the elevator shafts that the cables pass directly from the cars to the driving sheaves carried by the motor and then over and directly down to the counterweight, the motor shaft and sheave, in other words, displacing the overhead work of the usual construction and thus rendering all other sheaves unnecessary, with the exception of the idler sheaves immediately below the driving sheaves by means of which the second wrap around each driving sheave is secured for additional adhesion. The main bearings of the motor together with those of the idler sheave are the only frictional points encountered in the machine. The machines are self-contained, each combining on a single bedplate the motor driving sheave overhanging at one end and the brake mechanism, making a total weight of about 14,000 lb. Support was provided for the three units by a simple framework above the elevator shaft which is enclosed in a pent house that affords protection for the shafts and control mechanisms. The framework consists of four pairs of 12-in. 20½-lb. channels, which are so located upon cross girders supported by the building framework as to form bolting slots for the motor bed plates and the suspended idler shaft; the idler is hung directly below the driving sheave so that its support is a simple matter, as indicated in the elevation drawings of the machines at the top of the shaft and their methods of support.

The remaining structural features of the elevator equipments do not differ, except as affected by the location of the machines at the top of the shaft, from usual elevator practice, the usual form of T-rail guides being used for both cars and counterweight, while the speed of travel is limited by the usual form of Otis elevator governor. On account of the form of drive used and the location of the machines, however, these governors are made double-acting, arranged to operate the safeties in either direction of car travel, both upward or downward. The car safeties or guide grips are also arranged to be operated by emergency levers in the cars, if necessary. Furthermore, the ropes are not connected positively to the driving sheaves and there is no fixed relation between the position of the car and the position of the driving machinery. The limit stops, which prevent overrunning the limits of travel, consist of special switches at the top and bottom of the shafts, which are operated by cams upon the cars that act upon the control system. In addition to these provisions, there is an extra precaution taken in the attachment of oil buffers to the bottoms of the cars and counterweights, which are arranged to bring them to rest at the lower limits of their travel independently of all other devices; the efficacy of this means is evident from the fact that, if all other safety devices should fail, either the car or counterweight buffers would strike the impact blocks at the bottom of the shaft and prevent further descent so that continued motion of the elevator machine motor would result only in lifting the suspended weight sufficiently to allow slippage of the ropes.

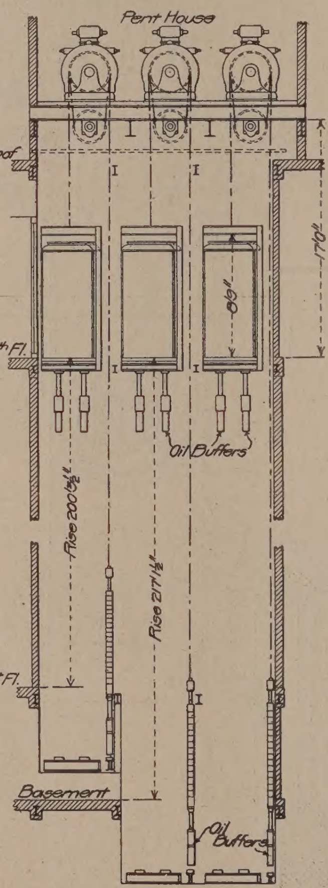
The elevator machine motor is a six-pole direct-current motor of special design for the required capacity at the slow speeds of operation necessary, arranged to operate normally at 60 r. p. m. It is wound for operation at 250 volts, current being supplied to the building from the Edison street service. The controllers consist of series of magnet switches, mounted on switch panels with the resistances, near the machines in the pent house at the top of the shaft, and have the usual features of utilization of the increasing counter-electromotive force of the motors, in starting, for operating accelerating magnets to cut out gradually the armature resistance and finally introduce resistance in the field circuits, and retarding magnets, similarly used for slowing down in stopping. The holding brakes on these machines are of a special design, with double-acting solenoids above the outer main bearing caps which operate specially designed shoes that act upon large drums on the motor shafts. The brake shoes are leather lined and carefully fitted to the drum, and are operated by a special toggle motion requiring but a very slight movement of the solenoid core to grip the drum firmly. The solenoids are operated in conjunction with current limit switches which allow comparatively heavy currents to pass through them during the action of releasing the brake, but reduce the current flow to a fraction of its initial value while the shoes are merely held in release position, against the pressure of helical springs in compression.

Locomotive Smoke Prevention has been demanded in so many cities of late and is so desirable for the comfort of passengers that it was thoroughly discussed at the recent Chicago convention of the Traveling Engineers' Association. The unanimous sentiment was in favor of a brick arch for preventing smoke and protecting tubes. It was stated to assist materially in mixing the inflowing air with the gases of combustion, thus supplying oxygen and preventing the formation of smoke. The hot brick also help maintain proper combustion temperature when the engine is standing and gases are still coming from the coal.

Factory Lighting.

In a paper with the above title, read before the Ohio Electric Light Association, at Toledo, last month, Mr. A. P. Biggs pointed out that from the standpoint of illumination, the lighting of factories may be divided into space and applied lighting. For general space and floor lighting there must be some large source of artificial light, and the sources now available are the electric and gas arcs, the Cooper Hewitt and the Nernst lamps. The incandescent lamp in large sizes is still inefficient as compared with these others, and in ordinary sizes does not give the necessary illumination.

An arc requires minimum cost for installation, has the greatest efficiency per watt expenditure and lowest maintenance cost. The unsteadiness of an arc is not serious in space lighting, and while the shadows from a single arc are apt to be annoying, the arc on the whole is the best unit for such work as above noted.



Traction Elevators in No. 1 Wall Street Building.

The Nernst lamp is desirable in small space lighting, in low-ceiling machine shops, and in foundries. In one instance where the Nernst lamp is giving excellent results, the lamps are spaced from 8 ft. to 10 ft. apart at a standard height of 9 ft. The light is soft and pleasant, and energy consumption low.

For particular application of artificial light, single incandescent lamps are the sources used. Although the installation of a lamp at each machine in every kind of business is not sanctioned by all illuminating engineers, it has the sanction of custom, the recommendation of the wiring contractor, and enjoys the hearty endorsement of those responsible for getting the same amount of work out of the machine by artificial light as is expected by daylight.

In a shop having low ceilings and much window surface, illumination may be good from natural sources for the first six months or so, but after that, by continuous process, the windows, ceilings, walls, posts and everything blacken and cease to let in or to reflect any light. The lighting installation fares the same way, and the workman shades his eyes by covering the lamps with anything available, until there is almost no light available.

An example of shop practice with individual lamps—uncommon because definite data accompany it—was presented by Mr. K. C. Keech, before the Chicago Section of Illuminating Engineering Society in May last. A bare lamp, 13 ins. above the face-plate of a drill press, and 7 ins. from the center, gave 3.7 ft.-candles at the center of the face-plate. The dirtiest lamp in the shop when substituted, gave 1.55 ft.-candles, while a new clean lamp in the socket gave 5.7 candles.

When the customer gives us the opportunity of making recommendations upon his equipment, we generally advise him to place at every machine a drop or bracket lamp with reflector, and that he use 8-cp lamps wherever possible. Often, to satisfy the customer that the economies pointed out are worth securing, we loan him a half dozen styles of shades and reflectors, and he purchases when he has determined the kind most suitable. Further—and here the policy of the company may seem heretical—space lighting is often disposed of by advising and urging the use of gas arcs. All possible short-hour burning is turned over to the gas company, and the electric light company is relieved from the "lighting bill" complaint which formerly afflicted us for several months each winter. As this policy results from our differential rates, its presentation may be comforting only to those who make high prices per kw-hour for lamps burned but few hours per year; unless the "Flat Rate" man wishes to mend his way.

The usual factory lighting can be considered by central-station men as none other than unprofitable business, which is to an extent a necessary evil. By reason of its character, it requires all of the attention and all of the equipment which more respectable branches of the industry necessitate, but refuses to make adequate return on the investment and work to supply its need.

The assumption is not to be made that the Detroit Company is securing proper and adequate return for its service in this branch of lighting. The company has certain rates and is, as a public service corporation, required to furnish and does furnish service for all customers. Further, it is needful that this unprofitable business have a fairly low rate in order that we get the profitable business that goes with it.

The rates at which this class of lighting is sold in Detroit are as follows:

First—Open Order—Sixty hours' use per month of the demand at 16 cents per unit, balance at 4 cents per unit. This agreement is not a contract, having no definite term.

Second—Demand Contract—Thirty hours' use per month at 16 cents per unit, balance at 4 cents per unit; minimum bill 30 hours' use per month of maximum demand at 16 cents; term, one year.

The following discounts for prompt payment are allowed on both agreements: On bills less than $50, 10 per cent; on bills of $50 and less than $100, 15 per cent.; on bills of $100 or more, 20 per cent.

Under "open order" we furnish standard incandescent lamps and renewals—and trim and care for arc lamps and Nernsts owned by the customers. Under "demand" we furnish all incandescents, arcs, Nernsts, renewals and maintenance.

The "open order" is the most common prescription for factory lighting. It cares for that class of customers whom we term "short hour," who use our service as auxiliary to sunlight and daylight; who have a few places which, due to poor construction of building, blackened windows, or later construction by their neighbors, need light occasionally during the day, but whose principal service is from dusk to 5:30 p. m., and who either cannot or will not make nor pay us for making the investment necessary for good lighting.

The "demand contract" is suited to the lighting conditions of but a small portion of factories, inasmuch as it is designed for the satisfaction of long-hour burners. The factory whose conditions are met by it is probably one in which there is a requirement for a large number of individual lamps, and for small lamps in isolated parts of the factory, for which there is necessity for service all through the day.

To illustrate that under our rates factory lighting is unprofitable to us, the following cases have been figured to show cost to consumer under "open order" and under "demand contract," and the amount the business should have brought in in order that it might just begin to be profitable, the later amount being arrived at as fixed charge per kw-year plus operating costs per kw-hour:

				Earnings	Income per Year	
	Kw.-h.	Connected Kw.	Demand Kw.	Open Order.	Demand Contract.	Minimum Allowable.
1..	4,330	29.0	12.0	$552.00	$632.00	$780.00
2..	8,163	36.6	13.5	916.00	815.65	973.89
3..	1,800	5.6	2.2	220.00	157.00	172.30
4..	6,850	30.6	22.2	884.00	1,061.70	1,410.80
5..	10,410	26.3	17.6	1,168.70	875.80	1,262.80
6..	3,052	16.6	9.16	416.70	492.93	500.40
7..	1,644	5.1	2.81	226.72	170.25	201.10

Nos. 1, 2, 3, 4, 5—On Open Order, 60 hours' use of the demand.

No. 6—On Demand Contract.

No. 7—On Open Order, 60 hours' use of connected load.

The first three calculations are for a carriage manufacturer, in successive stages of his business. For two years he did all his lighting by clusters; at the end of that time, by reconstruction of building, the electric lighting was reduced from 13 kilowatts demand to 2 kilowatts, and all general floor lighting was done by gas arcs. Only on this third year, after the changes had been made which took from us the pleasure of serving 650 lamps, did we make any profit on the business.

The fourth and fifth calculations are successive years in a cigar factory—a six-story building lighted throughout by incandescent lamps. At the end of the first year given, the customer was persuaded to change 300 individual lamps from 16 candle-power bare to 8 candle-power lamps with reflectors. Demand was reset and he was billed upon 60 hours' use by its readings—as he was an open-order customer. He saved considerable and we only lost 10 per cent. on the lighting business, against 60 per cent. the year before. His motor business in the last year amounted to 30,800 kw-hours, with a demand of 11.6 kilowatts.

The sixth is a manufacturer of shirt waists, skirts, etc.; has all electric equipment, using electric arcs for general floor lighting. His lighting business, which was on demand contract, lost us but $8. During this year we had the profit from the sale of 20,000 kw-hours for motors with demand of 8.5 kilowatts.

The seventh, which is a bathtub factory, has wood-working, sheet metal and brass foundry departments. For space lighting gas arcs are used, and the business gave us some respectable return.

As a public service corporation having established rates we must sell at these rates whether the customer causes us to lose on service or brings us revenue from it. We tell customers that by our experience his lighting will be cheapest for him, say, on demand, but inform him that there are so many conditions of surroundings, location of lamps, faults of building design, amount of natural lighting, etc., that he must fix his conditions and try it out for himself. Usually we install such service on open order—if we find later that demand contract rate will be to the customer's advantage, we offer it to him.

Our rates are based on customer's demand even when the open order is taken. If demand is same as connected load, and the customer signs the open order, we will bill him at 60 hours' use of the connected load at 16 cents. If his installation is greater than his demand, we install demand indicators and bill on showing of indicators. If he has many empty sockets in his installation, we install demand indicators, and probably bill on connected load until demand shows that customer has fitted empty sockets with foreign lamps and would have us continue to bill him without increasing his rate.

By the same method of figuring as used above, a business begins to be profitable to us when the customer has paid for 480 hours' use of demand per year at 16 cents, say, 40 hours per month. As an approximation—to get at classification of business as profitable or unprofitable—the consumption of energy per year of factories as found in several customers' ledger accounts, has been divided by 12 times demand, giving hours' use of demand per month. All of these factories are operating on a regular 10-hour day.

No. of Cases.		Average Hours' Use of Demand per Month.	
5	Bakeries, Wholesale	107	
8	Brass Works	57	
2	Breweries	85	
2	Brush	12	
4	Candy	51	
3	Chemical	10	
7	Cigar	29	
9	Clothing	37	(5 cases average 11.9)
3	Engravers	70	
3	Harness	35	(2 cases average 11.9)
1	Knitting	9	
14	Machine Shops	31	(7 cases average 13.4)
3	Paper Box	13	
4	Printing	20	
8	Sheet and Metal	18	
3	Sheets	33	(2 cases average 13.7)
2	Toys	31	
1	Upholstering	4	
1	Wire Works	12	
6	Woodworking	24	(4 cases average 11.10)

From their nature, several kinds of business are invariably profitable. The wholesale bakers use some lighting for 24 hours per day. Breweries have many small motors about their establishments which are shut down about 4 p. m., and the lighting load up to that time continues quite uniform throughout, making the lighting demand negligible.

Machine shops and brass works need electric lamps for individual machines only, and give a good lighting load summer and winter. The clothing manufacturer, whose record makes the best showing of his class—to our way of thinking—in the above list, has on each machine a movable arm carrying a lamp of low candle-power with parabolic reflector, permitting operator to bring source of light close to work without unpleasant effect on eyes; all his space lighting is by gas arcs.

We persuaded one customer operating a brass foundry to put in gas arcs for all lighting, and further satisfied him that, with little hardship, his air compressor could be shut down in the afternoon at such times as would prevent any increase of total load due to shop lighting. As a matter of general policy, in addition to giving other advice, we recommend to the manufacturer that a fraction of the amount spent this last year for lighting be turned over to a window cleaner and a man with a hand-pump and a tank of whitewash, expecting that both of us will then be satisfied with his factory lighting.

Our conclusions are: That an electric light company cannot afford to take on all factory lighting offered to it; that it is obliged to take a certain amount which is inherently unprofitable; that it should minimize this amount (first) by advising the customer how to reduce his demand by utilizing light to best advantage; that is to say, by good illuminating engineering; (second) advocating the transfer to daylight hours of any motor load that can be dispensed with during the evening hours, and (third) by passing over to the gas company such factory space lighting as can be profitably furnished by gas arcs, retaining for electricity the long-hour localized lighting.

It is worth while to note that the new metal filament incandescents may modify these conclusions. They will not change the rates of demand to sales, but they may make gas so comparatively expensive as to put it out of competition either partially or altogether.

In a paper with a similar title, J. T. Kermode stated that many manufacturing concerns are vacating their old premises to enter buildings of more modern construction, with saw-tooth roofs and windows on practically four sides, which is evidence that better lighted workrooms are essential and that the demand for a higher standard of artificial illumination is rapidly increasing.

The short-hour use and usually heavy demand on the station peak has brought about a condition where there is some question as to the advisability of factory lighting from a supply company's standpoint; it is, however, very important when combined with the supply of electricity for motors. In conjunction with this latter business considerable work has been done in Cleveland, where it has been the policy to make surveys, plans, specifications and to obtain bids for this class of wiring with special reference to the best and most economical method of illumination for the various kinds of work in different processes of manufacture.

The average factory requires artificial light during 10 to 20 per cent. of the working hours, not including overtime or night shifts; therefore, the illumination should be sufficient and the lamps so arranged that the quality and quantity of work accomplished during these hours can be as well and economically done as that which is performed by daylight.

The amount of light required varies, first, with the size of room, relative position of machines and the general shop conditions, and, second, with the character of work to be done. The arrangement that will effectively light a clothing factory cannot be efficiently applied to industrial plants, where the atmosphere is filled with smoke and dust.

Experience has taught that no general rule can be laid down to govern the many different situations that present themselves, but each factory must be studied separately to determine the amount of light, style of illuminant and the method of its installation, to give the best results.

For instance, large units cannot be successfully operated in roundhouses or car shops. The principal parts of locomotives that need special attention are so located, that, to be of value, the source of light must be reflected from each side of the engine. Five 100-watt Gem lamps, spaced 15 ft. apart, at an elevation of 7 ft., will light in a very satisfactory manner one side of two engines. Oil torches so commonly used in cabs, boiler and floor pits, can be conveniently done away with by the use of portable incandescent lamps

In foundries, forges, steel mills, structural iron works and boiler shops, where the walls are dark and the work does not require concentrated light, a lamp is needed that will give good general illumination Enclosed arc lamps, giving a white light, combined with shadows, are undesirable for this class of work, as the dark walls and dense atmosphere absorb a large percentage of their penetrating powers

The color and brilliancy of light produced by the flaming arc has attracted the attention of many manufacturing concerns, and, notwithstanding the cost of lamps and carbons, they are being extensively used to light large areas

In a large mill operating steel presses, 16 enclosed arcs were installed. On account of the dense atmosphere these lamps were hung below the tops of the presses, resulting in heavy shadows being cast around each machine. The 16 enclosed arcs were recently substituted by six flaming arcs. With slight changes in the wiring these arcs were placed 22 ft. from the floor, resulting in the entire shop being flooded with a warm, bright light.

The use of flaming arcs reduced the connected load, and averaging two hours use a day, these lamps would save 234 kw-hours per month, which at the usual prevailing rate for energy would more than compensate for the cost of carbons, without considering the increased amount of illumination.

It is generally conceded that the best uniform illumination can be obtained by distributing small units over the space to be lighted, but this is not always practical, for one must consider the building construction, and purpose for which the space is to be used.

The use of higher candle-power arc-lamps for factory lighting is rapidly increasing and the advantage that can be obtained by their use and efficiency must be recognized. The efficiency with which the light is produced and utilized, are two important factors, with which a supply company is intimately concerned.

In machine shops it is common practice, together with large units for general illumination, to furnish each workman with a single incandescent lamp, which when new, and at average height from his work, usually gives a fair amount of light. Oil and dust soon reduces the illumination one-half.

But it is not expected that the amount of work should reduce in the same proportion. Some reasons why this practice has become so popular are:

First. That up to a few years ago the majority of industrial shops were equipped with generating apparatus, but the cost of electric lighting was charged against the operation of the shop, and not against the cost of electricity, as it should have been.

Invariably, I have found, that where light is obtained in this manner, the generators, feeders and branch circuits are heavily loaded with inefficient apparatus and there is no incentive to economize.

Second. Wherever a large installation is necessary, the manufacturer usually employs a man to look after the operation, repairs and additions to the electrical equipment.

These men, as a rule, are not familiar with the improvements that are continually being made on the various devices that go to make up a modern electric installation. Consequently, inefficient light facilities are unintelligently installed.

Third. Employees have been educated to believe their work cannot be successfully performed unless each individual is furnished with an incandescent lamp, and realizing the flexibility of electricity, it seems comparatively easy for one to convince the foreman that an additional lamp should be added here or there, resulting in an over-lamped room for the number of machines operated and also in a poorly lighted room at an excessive cost.

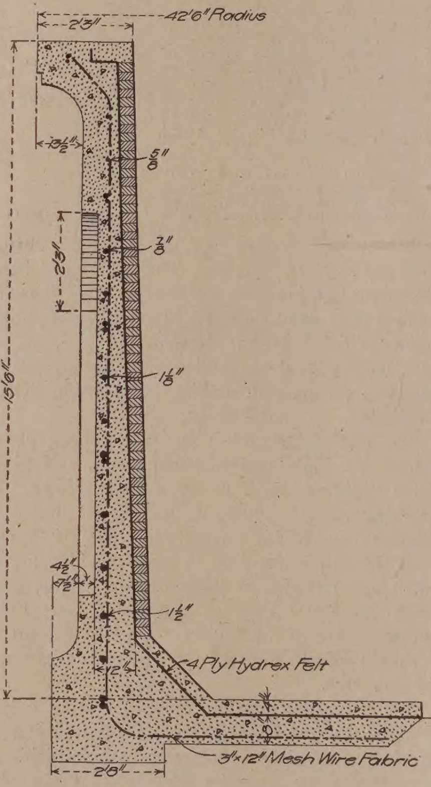
In machine shops where lathes, drill presses, planing machines, milling machines, screw machines, punches, etc., are used good general illumination of uniform intensity is required. Nernst or Gem lamps are well adapted for this class of lighting.

The size and number of lamps to be used depends upon the size of the room, height of ceiling, color of walls, location of machines, belts and shafting. In estimating the size and number of units it might be of service to consider 50 watts per operator, or machine, as an average amount for all ordinary machine work and general illumination. For special machines or work needing bright light, individual incandescent lamps with reflectors should be used. Machines that are automatic in their operation are many times provided with unnecessary individual lamps. Appreciating that these machines do need good light for changing their adjustment, the use of portable lamps that can be connected to receptacles near each machine will, if intelligently used, save energy.

The general evenness of illumination with the absence of glare, together with the easy shadows and searching quality of the light produced by mercury-vapor lamps makes them especially adaptable for factory lighting by direct current. Unfortunately the alternating-current lamp up to the present time has not been successful, due to its inability to readily start.

Manufacturers of clothing require an even, shadowless, well diffused light of considerable brilliancy. Nernst lamps with prismatic reflectors can be utilized for this purpose with a comparatively low consumption per operator.

The difficulties that exist in factory lighting are familiar to all men engaged in the sale of electricity and it should be the duty of each central station to educate its men to successfully overcome these conditions by encouraging the use of lamps, shades and reflectors that have been produced for scientifically converting wasted energy into useful light. Recent discoveries in the production of electric lighting are of revolutionary nature, the same principles which have been utilized in the cheapening of gas light, that is, the use of the peculiar properties of rare earth and metals, have been appropriated by the electrical interest and the recent developments indicate the efficiency of electric lamps will be doubled in the near future.



Section of Wall, Cos Cob Reservoir.

Recently I have read an article in which a supply company recommends the use of gas for factory lighting that they might be successful in retaining power business.

Is there a more exaggerated case of false economy than that of requiring people to work by poor illumination? In comparison with the cost of labor, the cost of lighting is trifling. Take, as an illustration, the case of a skilled workman receiving $3 or $4 a day (say, an average of 30 cents an hour or ½ cent a minute), figure the cost of a 16-cp lamp burning 10 hours, and see how many minutes of the man's time it requires to pay for the light. Yet there are thousands of skilled mechanics handicapped with insufficient and ill-directed light.

A Concrete Power-Plant Reservoir.

A 600,000-gal. reinforced concrete reservoir, 80 ft. in diameter and 15 ft. deep, of attractive appearance, has been constructed for the New York, New Haven & Hartford R. R., at Cos Cob, Conn., in connection with the power plant described in The Engineering Record of Aug. 17, 1907. The reservoir is founded on solid rock and is without any surrounding fill, thus making some exterior embelishment very desirable. Accordingly the wall was designed with a cornice and a slightly projecting base and the flat belt between was relieved with a series of arched indented panels, forty in number, giving somewhat the effect of an arcade. The general appearance of the exterior of the tank is shown in an accompanying illustration.

The concrete wall has the form and dimensions shown in an accompanying sketch and has a 4-in. lining of brick laid up in cement mortar to protect the waterproofing coat. It is reinforced circumferentially with steel cable, varying in diameter from 1½ in. at the base to ⅝-in. at the top, forming a continuous spiral with 12-ft. splices made with sixteen Crosby clips where the ends of two sizes of cable are joined. The pitch of the spiral varies somewhat, as indicated on the drawing, but is in general about 1 ft. Inside the cable spiral is a continuous sheet of 3x12-in. mesh Clinton wire fabric, placed in vertical strips which extend 6 ft. into the floor foundation.

The inlet and outlet pipes are 10 and 12 in. in diameter, respectively, and enter through the floor of the tank near the east wall. Watertight connections were secured where the pipes passed through the waterproofing by clamping a sheet of lead between two flanged screw sleeves, as shown in an accompanying sketch. Just outside the tank wall the two pipes enter a concrete valve chamber, 5⅔x11⅓ ft., in the top of which is a 30-in. manhole. A 3-in. steam pipe leading from the power house through the valve chamber into the tank and half-way across the floor, with a perforated upturned end, is provided for keeping the water above the freezing point in cold weather.

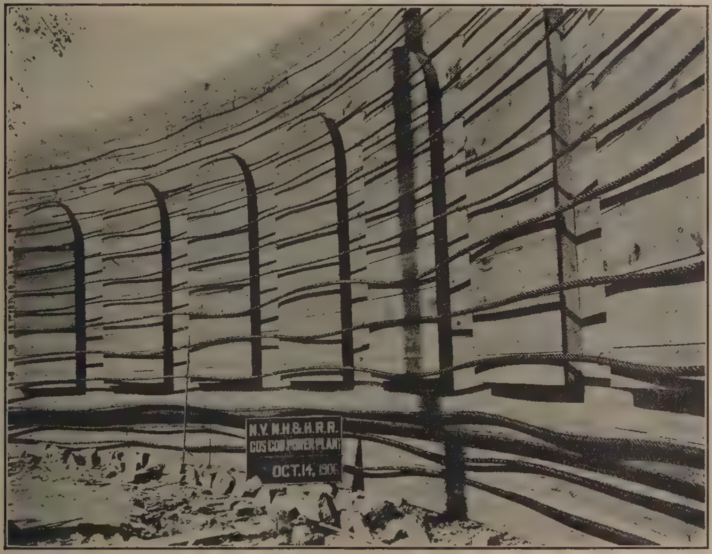
The natural surface of the granite outcrop on which the tank is built sloped considerably to the north. To make a level foundation the rock on the south side was blasted out and transferred to the north side, the rock fill being thoroughly compacted and grouted with cement and sand mortar until it was a practically solid mass.

The wooden form for the exterior surface was built complete from the foundation to the coping and around the entire circumference of the tank. Screw hooks were then driven into the inner surface of this form, properly spaced to support the cable spiral. The cables were then hung on the hooks, the proper spacing between these points of support being maintained by wire ties, and upon the cables was wired Clinton electrically welded wire fabric in vertical strips as indicated on the drawings. The interior of this form, with the cables hanging on the hooks before the wire ties or wire fabric were attached, is shown in an accompanying illustration. The vertical supports for the inner forms were erected after all the reinforcement was placed and were wired to the outer forms at the proper distance. The concrete was prepared in a mixer placed just outside the tank, and delivered to place in 1-yd. skips by a guyed derrick placed in the center of the tank and operated by a hoisting engine which was outside the enclosed area. The derrick cables were run through the wall, the holes being filled after the forms were removed. The inner form was built up a few feet at a time as it was filled with concrete, which was placed very carefully to insure the filling in of all spaces between the cables, wire fabric and forms.

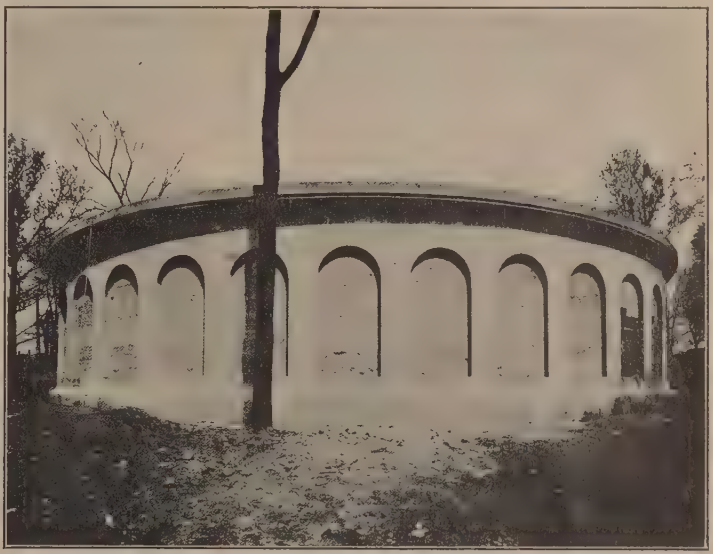
About ten days after the filling of the wall forms had been completed the forms were removed and the derrick was taken out of the tank. The floor was then concreted to an even surface and a 4-ply waterproofing coat of Hydrex felt was applied to the inner surface of the wall in vertical strips and to the tank floor. Hydrex compound was used to cement the layers of felt together.

A 4-in. protective covering of concrete was laid over the floor of the reservoir on the waterproofing coat and extending a little way up the side to give a footing for the 4-in. brick wall lining. The bricks were laid with cement mortar with a solid backing of mortar between brick and waterproofing.

The reservoir was designed and built by Messrs. Westinghouse, Church, Kerr & Co., of New York, engineers and constructors of the power house.



Inside of Reservoir Forms with Cables in Place.



The 600,000-Gallon Reservoir at Cos Cob Power Plant.

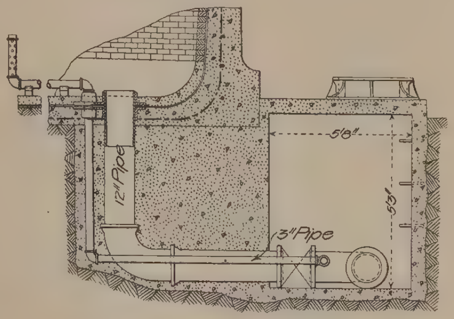
Electrical Equipment for Suburban Lines.

Electrical equipment for the suburban lines in Oakland and vicinity belonging to the Southern Pacific was ordered recently. The service given is distinctly of a suburban rapid transit character. The commuter traffic is confined largely within a radius of about seven miles, and the different roads conducting this service converge at Alameda Mole where they connect with ferryboats to San Francisco. The stations on the suburban lines average four-tenths of a mile apart, and the system as a whole is said to do a larger suburban business in number of passengers carried than any other in the country, the Illinois Central suburban lines out of Chicago alone excepted. The electrical equipment now decided upon will consist of multiple unit trains with from three to twelve cars per train, made up in the usual combination of motor and trail cars. The cars seat 80 passengers each. Eighty motor cars have been ordered and each will be equipped with four General Electric 125-h.p. motors. Direct current will be employed and overhead catenary construction will be installed. The power station will be equipped with two 5,000-kw., 25-cycle, 13,200-volt, three-phase units, the contract for which has been awarded the Westinghouse Machine Co. Parker boilers have been ordered for the plant and Worthington condensers and auxiliaries.

Electricity for Cement Plants.

A paper read before the Association of American Portland Cement Manufacturers by Mr. J. B. Porter, of the Light and Power Department of the General Electric Company.

The applications of cement have been so enormously increased in the last two years as to almost justify the name for the present period as the cement age. This increased demand and the high prices which have been maintained have created a large number of new companies, and have stimulated the remodeling of old plants to increase their output. It is predicted that the total output of cement for 1907 will equal, if not exceed, 60,000,000 bbl.; yet this supply, it is claimed, will fall far short of the demands.



Section of Valve Chamber.

The object of this paper is to point out some of the special advantages of the electric drive in the manufacture of cement, both in economy and flexibility. From the economical standpoint the savings of one cent per barrel on a 1,000-bbl. plant would justify a first cost of over $50,000. Economy in the manufacture of cement is so closely connected with flexibility that it seems almost one and the same thing. Economy to cement manufacturers means continuous operation, and continuous operation is contingent on flexibility.

There are few if any plants which are not making good profits under the present condition of prices; yet there are any number of plants which are producing cement at a high cost of manufacture because of the inefficient layout of their plants and the uneconomical transmission of their power.

The cement industry has been very conservative in the adoption of electricity for the transmission of power; yet in most other lines of manufacture, mechanical transmission has been superseded by electricity even at great expense, and the results have proved that the electric drive has either increased the output, simplified the process of manufacture, improved the economy, or made easy the superintendence of the plant. Many Western cement plants are already driven throughout by electricity, and yet in the East, the cement manufacturers use the electric drive only where the mechanical drive is impracticable.

The cement industry opens a large field for the application of electricity. The simplicity of the manufacture of cement permits a division into different departments in such a manner that each department can be regarded as a unit, having its local manager who is held responsible for its satisfactory operation. With the electric installation, a ready record can be kept of the power consumed in each department, and the superintendent can easily locate the department responsible for any decrease in output for each day. A record of the power consumed in each department shows at a glance whether the consumption is above or below normal, and any deviation should require a satisfactory explanation or should indicate that the machines are not operating satisfactorily.

The profits in the cement industry demand the continuous operation of each machine at its full load; to obtain this, it is necessary to have flexibility in the power applied, and electricity permits of greater flexibility than any other mode of operation.

The installation in the power house of two or three generators insures a constant source of power for each and all departments. The switchboard, if properly subdivided and arranged with one feeder panel for each department, each panel equipped with indicating ammeter or recording wattmeter, furnishes a constant indication of the power consumed by each department, and a record of these readings gives a ready reference to the operation of each department. Each department may be operated by one or more motors; if more than one motor is used, the group drive should be made as flexible as possible so that part of the load, if necessary, can be thrown from one motor to the other, or the groups entirely separated from the others so that part of the department will always be in operation.

The output of a plant is based on the output of each kiln and the number of kilns installed; this department is the very heart of the industry and the successful manufacturer should provide every means known to keep his kilns running and crowd them to the limit of complete calcination.

To accomplish this there are three different methods of control, variation of the speed of the kiln, variation of the feed of raw material, and variation of the coal feed for combustion.

All these variations should be under the hand of the operator at the point where he can watch the calcination and change any or all of these to accomplish the most satisfactory results; here the application of the electric motor should play an important part.

Where it is necessary to use a number of crushers arranged in groups, the most flexible arrangement would be to select a motor of about 150 to 200 h.p. and drive from a line shaft, each pulley on the shaft to be equipped with a friction clutch. If the number of crushers requires more than one motor, put in another line shaft so arranged that it can be connected to the first line shaft by means of a friction clutch. Should it be necessary to add more groups, this can be easily accomplished by placing the crushers either in parallel or series, whichever arrangement will enable the feeding and taking away of the material to be more concentrated.

The power house, if properly designed, should permit the shortest steam transmission from boilers to engines, and the building should be so constructed that if it becomes necessary to increase the number of units beyond the capacity of the building, the end of the latter can be taken out and an extension made for both boiler and engine rooms without interfering with the continuous operation of the plant.

Electricity permits the grouping of the buildings for each department in the most convenient sequence without being obliged to take into consideration the source of power, and also permits the shortest transmission of the manufactured material from one department to the next. If possible, the building for each department should be constructed similar to the arrangement of the power house so that extensions may be added.

Up to the present date it has been almost impossible to obtain satisfactory tests even on motor-driven machines in cement plants, as the power required to start some of the machines is so great and changes so quickly that it is hard to take a reading; and the running power is so small in comparison that manufacturers have been compelled to use motors of large horsepower ratings in order to be on the safe side. There is now on the market a curve-drawing meter which automatically records the power consumed, and it is to be hoped that tests with it will put the consumer in a better position to specify motors nearer the running horse-power of the machine than they are at present.

For best results, motors, both direct and alternating current motors, should be run as near their most economical point as possible, which naturally is full-load rating. It is not always possible to take these points into consideration, as the limiting feature is the starting torque, which is generally from two to three times greater than the running torque required for most cement machines, yet with these curves, it will probably not be necessary to install a 150-h.p. motor to operate a continuous load of 65-h.p. as many of the plants are doing to-day.

The belt drive is generally considered the most satisfactory for transmitting power from the motors to the machines. It often happens that crushers get clogged and it is practically impossible to furnish sufficient power to start them again without cleaning them out. The belt drive relieves the motor from the enormous shock consequent on the stoppage of the machine and the belt would probably slip before the circuit-breaker could act, giving a double protection and also giving a protection to the cement machines that it is impossible to obtain from a mechanical drive, as there is no flexible arrangement that would automatically shut down the machine, mechanically driven, when excessively overloaded. The belt drive also relieves the motors from the consequent jar of heavy starting loads. At one cement plant where a crusher was driven automatically, a large-size shaft was twisted off by the clogging of the crusher with a sledge-hammer head. It is almost improbable that such an accident could have happened had this crusher been driven by a motor with an automatic circuit-breaker.

Until recently, it has been the practice to equip manufacturing plants with 220-volt direct current, chiefly on account of the great advance that has been made in that line of apparatus and especially where variable-speed motors were needed for certain machine tools where the requirements are such that the direct current motor is more advantageous.

The alternating current has many special advantages in the equipment of cement mills. The motors that are exposed to the cement dust are so simple in their construction that they do not need protection except dust guards for the bearings. The spare parts are so few as almost to be left out of consideration. The wiring and automatic protecting devices are enclosed in such a manner as to eliminate any sparking and consequent fire risk, and the motors are rugged and better suited to heavy overloads.

The alternating current permits the transmission of power at a higher voltage than is advisable with direct current, which will greatly reduce the cost of installation. It was estimated in one plant of several thousand horse-power capacity that the use of 600 volts instead of 480 volts showed a saving of over $8,000 on the installation alone.

For ruggedness, simplicity and continuity of operation, the turbine-driven generator has no equal. This point is well illustrated by the following quotation from a letter of one of your members operating a cement mill in the West: "The 800-k.w. turbine now in operation is giving splendid satisfaction and there is no question in my mind but that this type of power equipment is far and away the best for cement mill practice. We have had absolutely no difficulty of any kind or description in starting or operating this machine, and, from our experience so far, we are inclined to think that when once properly adjusted, the turbine will practically run without mechanical attention indefinitely." This letter refers to an alternating-current turbine-driven generator and was written entirely unsolicited. It was a comment on the turbine, while the letter was begging the manufacturer to improve their promise of shipment on a new turbine of larger capacity.

With the mechanical drive properly subdivided, dependence must be placed on one engine for one or more departments. Electricity gives two or three prime movers from which to draw power.

If one line shaft distributes the power in any one department, and it generally furnishes power to more than one department, any accident to that shaft might tie up the whole production of the mill. With electric distribution properly subdivided, it would practically be impossible to so cripple the plant.

A line shaft has to be installed not only of sufficient capacity for the total maximum load but with a big margin of safety, and this entire mechanical drive has to be run continuously whether one or all the cement machines are in operation. With the electric installation, the power is drawn only for the machines in operation and the efficiency of the plant is practically maintained.

Even if the kilns were driven by a separate engine and an independent shaft, any tie-up of either of these means of power distribution would shut down and seriously cripple the day's production. A delay of one hour on ten kilns would mean over $150 wiped out of the profits for the day, and it is seldom, if ever, the repairs can be made in one single hour with the facilities at hand. The electric drive in this department would save many hours of anxiety. Mechanical transmission cannot give you the flexibility or the output you can obtain from the electric drive.

Engineers ask how the electric can be as cheap or as economical as the mechanical drive. The dynamic power of the engine has to be converted to electric power with a generator and back again with a motor. That is perfectly true, but the commercial operation of a plant is a practical operation. With the mechanical drive, the plant is started and everything made to run smoothly, the load is thrown on and a lot of money and time spent to make tests on engines to ascertain the efficiency, which makes a fine showing. Take the same plant after a year's run and find what an enormous increase is demanded to accomplish the same result. It has been necessary to patch up here and there and to do it in the shortest possible time, for the plant must run, and instead of twenty or thirty per cent. loss in the mechanical transmission, this figure will be found enormously increased, although there is practically no means of knowing this except from the coal pile or more tests.

The electric transmission depreciates with far less rapidity than the mechanical, and any change or patchwork in the plant changes only a small percentage of the gross output of the power station. The instruments showing the power consumed are always visible and any increase in the demand for power is shown immediately; this fact alone would justify the electric drive where it is so important to operate continuously and to anticipate and to avert any trouble.

It is practically impossible for an electrical engineer to make satisfactory recommendations of electrical apparatus in a cement plant or any other kind of manufacturing plant without being perfectly familiar with the conditions under which the electric motor is to operate. This requires the hearty co-operation of the superintendent of the plant with the electrical engineer.

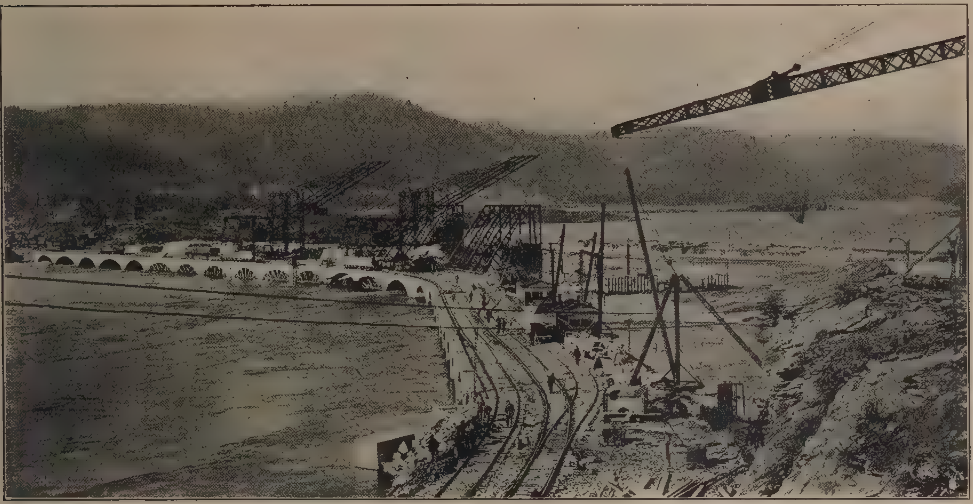
The keen competition of the present period demands the highest quality, together with the greatest output of material with the least possible cost. To be in a position to stand this competition, it is necessary for all manufacturers to use every means possible to bring their plants up to the highest points of economy and efficiency. It requires a man of strong character to seize the proper opportunity (which is generally dull times) to make these changes in his plant, in anticipation of the increased demand which will result from an inactive period.

A card index should be made of all generators and motors installed, and a record of any repairs or tests should be kept on these cards, the dates always being specified. The meters on the switchboard should be read at stated intervals during the day and night, and a regular record made and filed away for reference. These records will appeal to engineers, superintendents, managers and boards of directors; and such a file of records, if intelligently used, will put the cement industry on a scientific and economical basis heretofore unknown.

Boston Street Cleaning has been investigated for a citizens' committee of that city by Mr. R. T. Fox, whose work in Chicago was described in this journal on May 25, 1907. He found that the men he watched loafed a quarter of the time and cost of keeping horses was about twice that paid by business firms.

The Hydro-Electric Plant of the McCall Ferry Power Co.

There is now under construction at McCall Ferry, Pa., a hydro-electric plant having many unusual features in both design and methods of construction. It is on the Susquehanna River about 25 miles from Chesapeake Bay. The possibility of obtaining power from the lower Susquehanna has been realized for many years, but not until the McCall Ferry Power Co. began constructing its plant were any definite steps taken to profit by it. The originator of the project now being developed was Dr. Cary T. Hutchinson, who retained the late George S. Morrison, and in 1902 established gauging stations near the site of the plant now building to obtain definite information of the river conditions. Mr. Morison carried his work so far as to determine the site for the station, and the final studies and surveys resulted in the acceptance of this site.

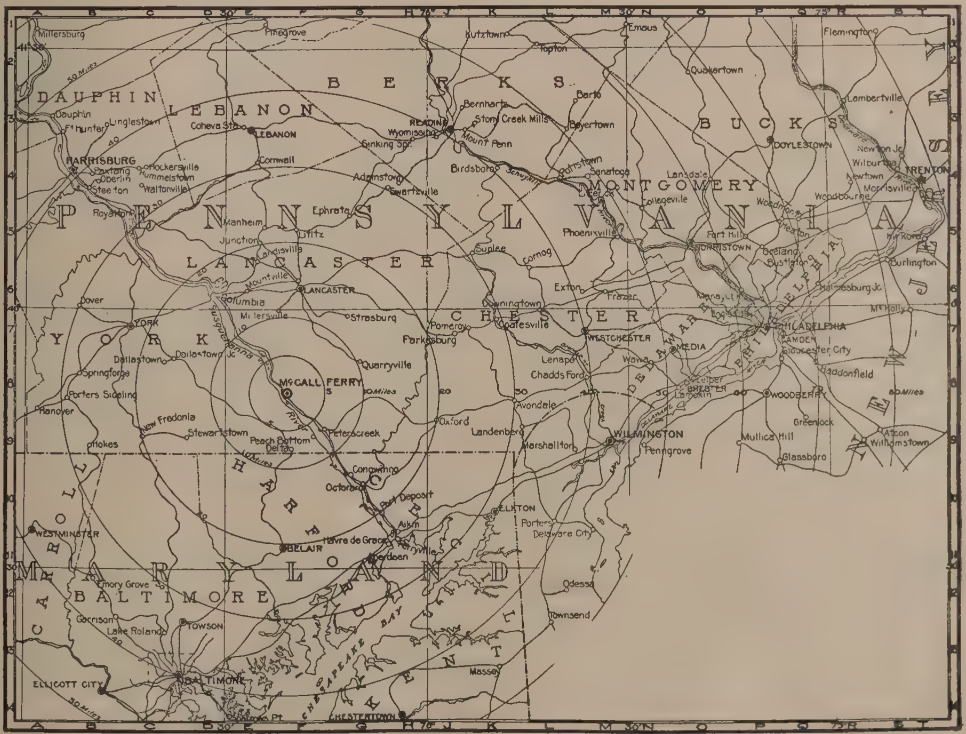


Construction Bridge and General View of Site.

The situation of McCall Ferry is exceptionally advantageous for a large power plant, being in the center of a large well-developed manufacturing district and a short distance from tidewater. Within a radius of 60 miles are Philadelphia,, Harrisburg and Chester, Pa., Wilmington and Dover, Del., and Baltimore, Md., and within 20 miles are many cities with populations ranging from a few thousand to 50,000, such as Lancaster, York and Columbia, Pa. The head of Chesapeake Bay, moreover, within 30 miles of the plant, offers in many small cities desirable factory locations accessible to large vessels. The present use of electric current for lighting, traction and manufacturing within a radius of 60 miles of McCall Ferry is great and the constantly increasing demand insures a large market. The McCall Ferry plant which is now making contracts to supply power in this territory has been designed for a nominal capacity of 100,000 h.p., half in an initial installation and the remainder developed by additonal units as needed. The total capacity for peak loads is 135,000 h.-p. on the turbine shaft.

Before the organization of the McCall Ferry Power Co. there were a number of plants projected at different points in the river both above and below McCall Ferry, which had secured water rights, and options on land. These developments were smaller than the station now being built, and the present company, having bought the rights of the smaller companies, was able to consolidate all the projects into two large ones. A possible site for another plant of 100,000 h.-p. exists at Conowingo, Md., 14 miles below McCall Ferry, and is controlled by the same company.

Hydraulic Conditions.—The Susquehanna River has a drainage area of 27,400 square miles, the larger part lying in Pennsylvania. Its watershed includes the steep slopes of the Allegheny Mountains, which cause sudden rises of rather frequent occurrence. The river occupies a deep valley, and for 125 miles above its mouth has an average slope of 3½ ft. per mile, the fall at McCall Ferry being 8 ft. per mile. The conditions on which the design of the plant is based have been studied at Harrisburg since 1890 and at McCall Ferry since 1902. The records thus obtained show that with the adopted head of about 55 ft. the flow of the river assisted by an adequate storage capacity can be depended upon for the continuous development of 100,000 h.-p. The storage will be secured by a lake 6 miles long and 4,000 ft. wide, formed by the dam. The discharge necessary to develop the normal rating of the plant on a 12-hour load is 10,000 cu. ft. per second, corresponding to an average run-off on the catchment area of 0.47 cu. ft. per second per square mile, the drainage area above McCall Ferry being 26,766 sq. miles. The discharge at peak load will be 27,000 cu. ft. per second. The flood flow considered in making the plans was about 671,000 cu. ft. per second; the record of the highest flood, that of June, 1889, corresponding to an average runoff on the drainage area of about 25 cu. ft. per second per square mile. The floods come with great rapidity, the flow in the river frequently jumping from 30,000 to 100,000 cu. ft. per second or over. The necessity of providing carefully for these conditions is further emphasized by the large amount of ice carried toward the end of the winter, much of it in large, thick cakes.



Map Showing Location of McCall Ferry.

Dam.—The plant and dam are built at a point where the river is about 2,600 ft. wide, and divided into two channels by Fry Island. The east or Lancaster channel is about 900 ft. wide, and the west or York channel about 1,200 ft., and the island about 500 ft. The stream is only 400 ft. wide a short distance above the dam, but the depth and swiftness of the current forbade construction there. The present site offers a ready means of handling the flow during construction by reason of the two channels. Above and below McCall Ferry the river is dotted with small islands and crossed by ledges, on one of which the dam rests. The water a short distance above and below it is very deep. Another such ledge crosses the river at Cully's Falls, and a channel had to be cut through it for the tailrace. The rock, though hard, is considerably eroded and fissured.

On account of the floods, the dam has been constructed as a spillway throughout its entire length of 2,350 ft. The dam extends only 600 ft. across the Lancaster channel, the remainder of the channel being spanned by the power house. Its crest is 45 to 50 ft. above the average summer water level. The section has been calculated for a head of 17½ ft., above the crest corresponding to a flow of 304.7 cu. ft. per second per linear foot of the dam, a quantity equal to the maximum recorded flow of the river. The section was calculated on the assumption that the weight of the masonry was 135 lb. per cubic foot and the weight of the falling water over the dam, and the pressure of the water on the apron were neglected. The base of the dam is uniformly 65 ft. wide, below a point 51 ft. down from the crest of the dam. Where the dam crosses the island, the ledge rises to within 41 ft. of the crest, necessitating a change in the section, which was made by retaining for the lower part of the apron the same curve as was used elsewhere, the only difference in the two sections being in the length of this lower curve of the apron. The front face is vertical.

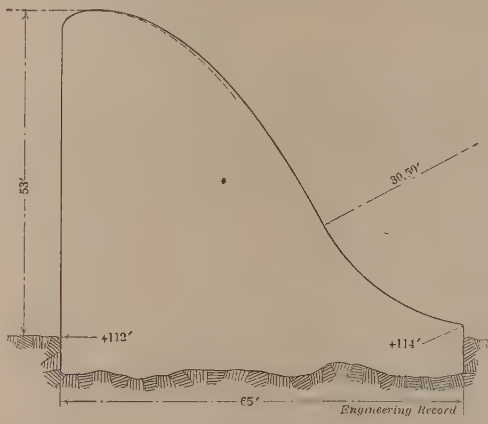
The dam is 1:3:5 Portland cement concrete with pudding stones up to 1 cu. yd. in size. Atlas and Giant cement are used. The sand is coarse and very clean, secured from a bank at Charlestown, Md. The stone is a very hard trap, weighing 193 lb. per cubic foot, used without screening, and contains pieces running up to 7 in. in length. The pudding stones are of the same rock, which is obtained at a quarry operated by the company at Conowingo, Md. These stones, forming 20 per cent. of the total yardage, are placed not closer together than 8 in. and 2 ft. back from the surface of the concrete. The amount of material in the dam is 174,000 cu. yd.

Power House.—The power house occupies the eastern part of the east or Lancaster channel, and stands at an angle of 42 deg. with the face of the main dam. In front of it is a forebay, where the racks and screens are located, and the entrances to the chutes for disposing of any ice which gets into the enclosure. The conduits leading to the turbines start immediately back of the inclined racks. They are built entirely of concrete, no steel being used either for reinforcing or for the intakes or draft tubes. The ten turbines are beneath the power house floor, five on each side of the two exciters in the center of the building. South of the power house is the transformer house, carried by arches spanning the draft tube outlets in the tail race.

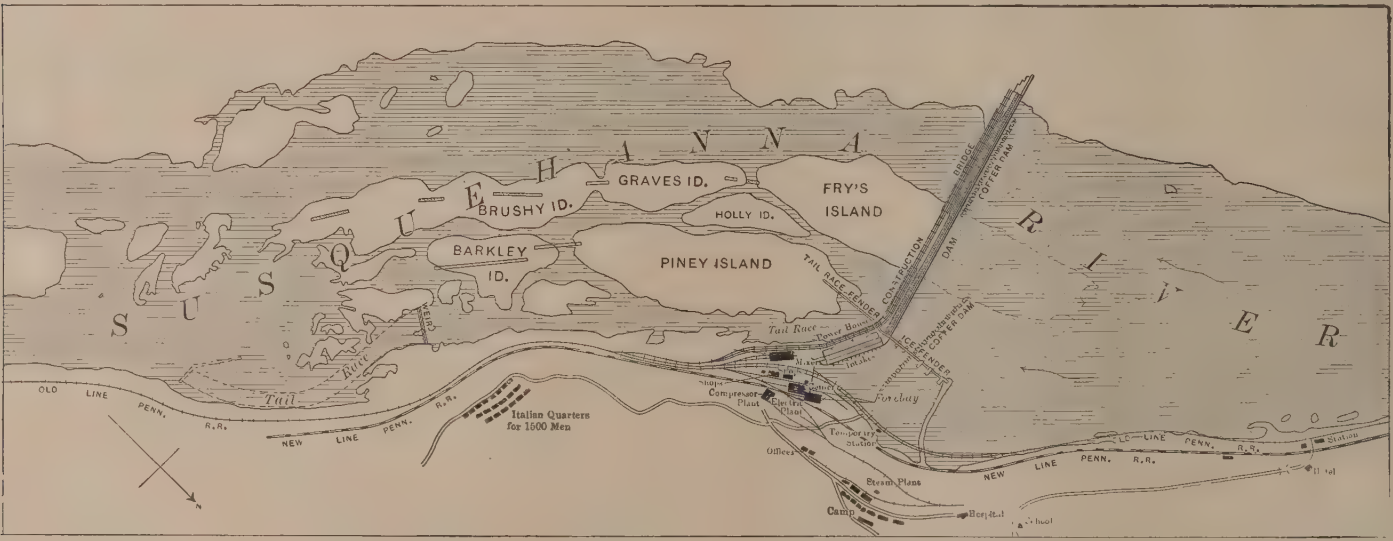
The front wall of the forebay is carried on eleven arches, the crowns of which are 6 ft. below the crest of the dam, and 1 ft. below the low water level, so that they will always be submerged. Back of the arches and carried on inclined piers are the screens, and back of them are the gates closing the intakes to the turbines. The screens are built in panels 10 ft. wide and 11 ft. high, four tiers to a unit. They have frames of 10-in. channels, supporting the screen bars, which are 7/16x4½ in., with 2-in. spaces between them. Instead of using gas-pipe separators, as is generally done, the bars will be kept apart by plates ⅜ in. thick, which have notches cut in them of the thickness of the bars. The strips of metal between the notches are bent over the rods on which the bars are hung, thus holding the latter apart. The frames slide in cast iron seats bolted to the noses of the inclined piers. This arrangement allows the screens to be withdrawn for repair and cleaning by merely catching them with a line from the crane, and pulling them out. Within the forebay are two chutes for disposing of any ice that may get by the exterior ice protection. One of these chutes 6 ft. square is located between the two exciters at the center of the power house, and the other measuring 8x10 ft. at the east end of the forebay.

The gates closing the intake conduits are 16 ft. high and 6 ft. wide, and are raised and lowered by the large traveling crane in the screen and gate room. An auxiliary gate also lowered and raised by the crane is cut into the main gate, and can be opened so as to equalize the pressure in the forebay and the intake conduits.

The intake conduits for the main units start in three openings separated by piers each 6 ft. wide and 16 ft. high. Eight ft. back from the gates these three passages merge into one which is 15 ft. wide, and for a short distance 13 ft. high, expanding as the conduit forms the turbine chamber to a height of 33 ft. There are two draft tubes one leading from each wheel of the unit. These draft tubes join about 20 ft. from the unit, but are here divided by a vertical wall, the discharge outlet into the tailrace of each unit being composed of two passages, each 13 ft. wide and 15 ft. high. This arrangement of the draft tubes, since they are constructed of solid concrete necessitated very complicated form work, especially since it was necessary to have easily curving surfaces which would offer little or no resistance to the flow of water. The exciters are located in the center of the power house with five main units on each side of them. The intake conduits and draft tubes for them are 6 ft. square in section.



Section of Dam.



Map Showing Location of Dam, Power House and Construction Plant.

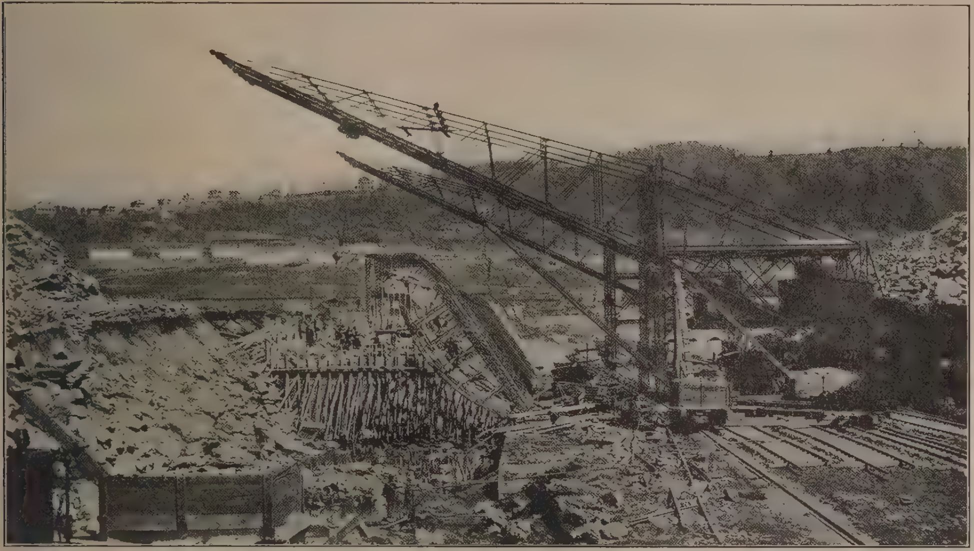
Each turbine is set in the concrete chamber without the usual steel or iron casing. Each chamber can be closed independently of all the others, and after being closed by the gates in front of the intake conduits and the stop logs at the ends of the draft tubes can be drained through outlets leading to pumps installed for that purpose.

Below the power house floor runs a chamber parallel to the length of the power house in which will be installed the pumps for draining the wheel chambers and the turbine-driven oil pumps for supplying the thrust bearings with oil.

The turbines are of the vertical shaft, inward and downward flow, Francis type, made by the I. P. Morris Co., Philadelphia. There are 10 main units each capable of developing 13,500 h.-p. under a head of 53 ft. with the gates open 80 per cent. at 94 r.p.m. Each turbine when run at its rated load will take about 2,700 cu. ft. of water per second. Each turbine has two separate wheels mounted on the same shaft, the latter being of forged steel, 20 in. in diameter. The upper wheel discharges through a steel casing leading to the draft tube while the lower wheel is set immediately over the draft tube pit, and discharges into it without the medium of a casing. The wheels are about 10 ft. in diameter.

The weight of all the moving parts of both generator and turbine is carried on a thrust bearing which is supplied with oil from pumps driven by small turbines. Separating the oil pumps in this manner from the main units allows the oil in the thrust bearing to be put under pressure before the unit is started. The thrust bearing which carries a total weight of 335,000 lbs., is supported by a lens-shaped casting set into the concrete. The exciters, also made by the I. P. Morris Co., have a capacity of 1,000 h.-p. and are of the same general type as the main units.

Ice Protection.—The large amount of ice which has to be disposed of and its long continuance each winter has necessitated special precautions for protecting the plant and turbines. It is aimed to keep the entire enclosed forebay free from ice and to accomplish this an outer forebay is provided and separated from the main river by a series of submerged arches and timber cribs, which form racks holding in place floating booms. This ice protection is 630 ft. long, and stretches from the point where the main dam and the power house join to a ramp 300 ft. long built out from the shore. The concrete ice protection consists of 3 submerged arches each having a span of 68 ft. with 8-ft. piers between them. The crowns of the arches are 2 ft. below the estimated low water elevation so that the arches are always submerged, the ice and floating debris being thus stopped and floated toward the dam, where a special runway for this purpose has been constructed between the main dam and the power house. The top of this concrete structure rises to a height of 22 ft. above the crest of the dam and 4½ ft. above the high water elevation. The top is 6 ft. wide and the back face has a batter of 4 in. to the foot, the piers at rock foundation being 30 ft. long. The space between the concrete structure and the ramp is occupied by four timber rock-filled cribs, spaced 104 ft. apart and supporting floating booms. These cribs are 24 ft. wide and 16 ft. long on top, the length increasing with the depth, being 64 ft. at the foundation. The floating stop logs between the cribs are made of three layers of six 10x12-in. timbers each. They are bolted together with spaces between them so as to make the boom 7 ft. 8 in. wide and 3 ft. thick. The boom slides in recesses in the timber cribs, rising and falling with the stage of the water above the dam. The direction of the ice protection is parallel to the flow of the river so that the flow will assist in carrying the ice and debris toward the main dam and over the runway.

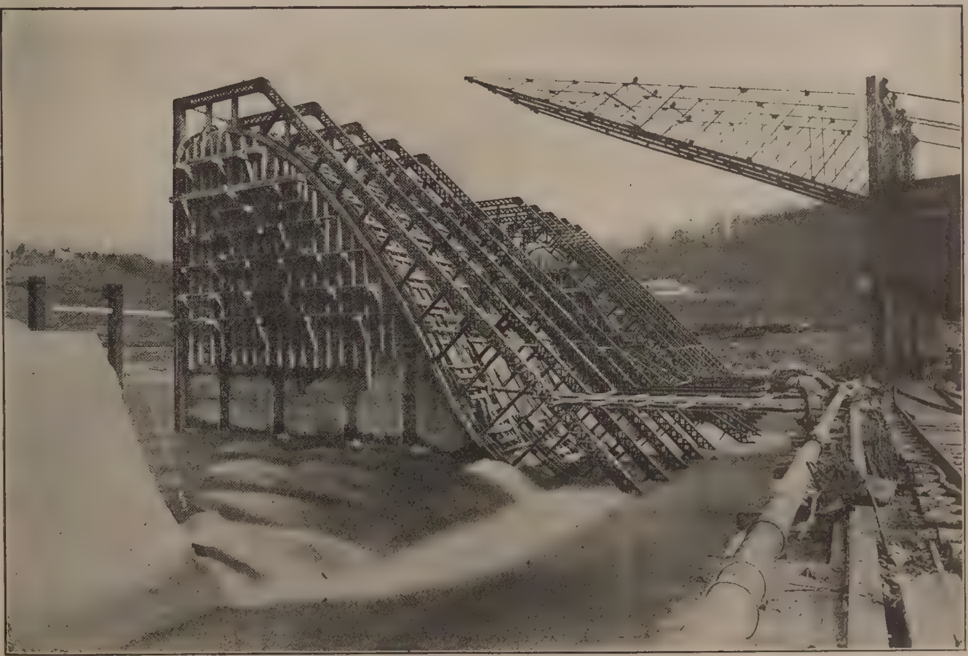


Excavation for Dam on Fry's Island.

In addition to this ice protection, a spillway has been provided between the power house and the shore for disposing of any ice which forms in the forebay or finds its way into it. This spillway 40 ft. wide has the same elevation as the crest of the main dam. Separating it from the power house and protecting the latter from the ice passing to the spillway is a wall 8 ft. thick reaching above the high water elevation. This spillway cuts off the power house from the shore and access between them is had by a bridge 5 ft. wide, and by a tunnel 14 ft. wide and 16 ft. high running through it. The tunnel is laid with a standard gauge track which extends 55 ft. inside the power house, allowing the machinery to be handled directly from the cars by the power house cranes.

Tailrace.—The tailrace, 3,000-ft. long, is nothing more than the former bed of the Lancaster channel, lying between the east bank of the river and the chain of islands south of Fry Island. This channel presents a very curious formation. The bed is of solid gneiss, with benches on either side submerged at the original condition of the river from 7 to 10 ft., and having between them a channel about 100 ft. wide and from 80 to 90 ft. deep, with vertical walls. This unusual depth continues until near the point where the tailrace flows into the main channel of the river. A ledge of rock is here encountered through which a channel 1,000 ft. long and varying in width from 150 to 300 ft. is being blasted. In order to prevent the river from flooding the tailrace by flowing through the openings between the islands which separate the two channels, rock filled timber cribs are being thrown across these openings, and carried above the highest level which the water in the channel can reach. At the point where the rock ledge obstructs the channel near the end of the tailrace a concrete weir will be built, with its crest at the same elevation as the top of the draft tube outlets, so as to preserve a water seal for the turbines.

In order to prevent a large volume of the water which comes over the dam from finding its way at once into the tailrace, and thus raising the level of the latter, a deflecting dam 576 ft. long starts at the junction of the main dam and the power house, just opposite the beginning on the upstream side of the ice protection, and runs over to Piney Island, which lies south of Fry Island. This dam will be built of solid concrete, using pudding stones and the proportions which were adopted for the main dam. Its crest will be at the same level as the power house floor, 14 ft. below the crest of the main spillway. With this dam, and the crib work between the islands below the plant, the water coming over the main dam, is confined entirely to the western or York channel, allowing the Lancaster channel to be used for the tailrace. The low water level in the latter will be about 15 ft. below the water level in the spillway channel immediately below the dam.



Pier Sections of Spillway Dam Showing Steel Forms.

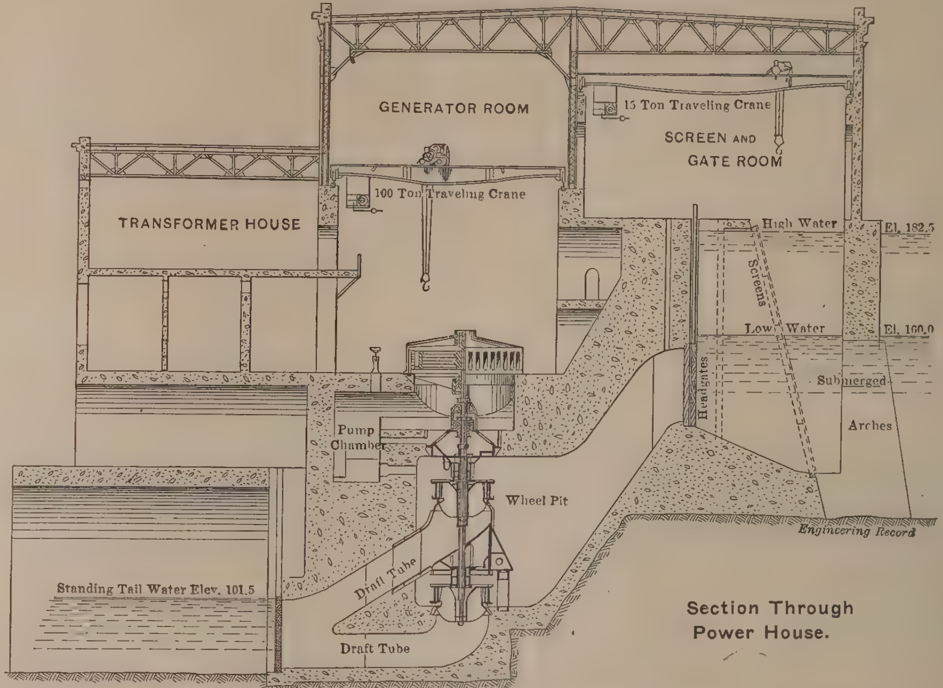
Construction.—The preliminary work such as the erection of the camp and cutting the timber on the side hills was begun in Nov., 1905, and in the following January with a full force. Work on the dam was started on Oct. 25, 1906. It is expected that the plant will be in operation in June, 1908.

Construction was first started across the Lancaster channel, which carried the greater volume of water and in which the power house is located. On account of the rapid rise of the river, and the large discharge during high water, the problem of constructing the dam was a serious one. To have provided against the maximum flood during construction would have involved great expense, while any less provision meant the occasional stoppage of the work, and the probable loss or damage of the construction equipment and the partially completed work. After a thorough study of all the conditions it was decided to construct a cofferdam sufficiently high to prevent being overtopped by a flood less than 60,000 cu. ft. per second. Since the inception of the work, daily reports regarding the weather conditions on the watershed have been received from the weather bureau at Harrisburg, and when a flood above 60,000 sec. ft. is on the way preparations are made to meet it. Such a case occurred on Mar. 15, 1907, when a flood of 320,000 cu. ft. per second swept over the work. Warning had been received and everything movable in the path of the water was moved to a place of safety, and work carried on without interruption until within an hour of the arrival of the flood, when the remaining equipment was run to cover. The flood did no damage to the partially completed dam and power house, but carried off four standard gauge tracks laid with 60-lb. rail which were on the construction bridge below the dam.

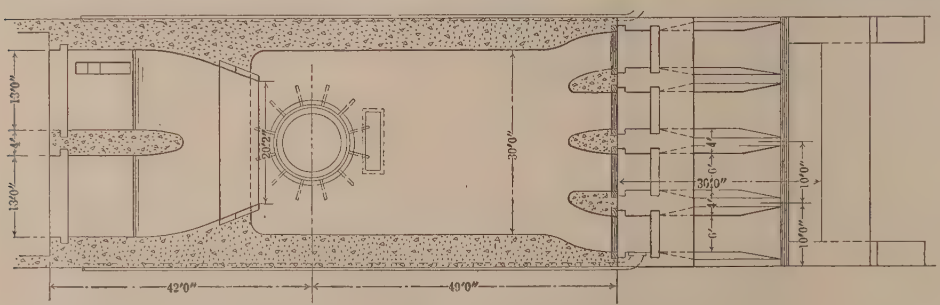
Cofferdam.—The first step in the actual work of harnessing the river consisted in building the cofferdam, a rock filled timber structure 1,000 ft. long and about 300 ft. up the river from the site of the dam. Soundings had been made across the channel at the places where the cribs were to rest, and where these did not give a satisfactory description of the bottom, divers were sent down to get more accurate information. The bottoms of the cribs were then framed on shore to fit the rock foundation on which they were to rest, and after having a few courses of timber built upon them were launched, towed into position, and held there by cables anchored on shore. They were then built up in the usual manner, the timbers, which were 8x10 in., being drift bolted together with 7/8-in. drift-bolts, 30 in. long. The materials were conveyed to the cribs by means of a Lidgerwood cableway with a span of 1,200 ft. over the site of the cofferdam. In addition to this means of conveyance, a standard-gauge track was carried out and extended over each separate crib as soon as completed, and on it was run a traveling stiff-leg derrick. Rock was placed in the cribs to sink them as the timber work was carried up. The cribs were 16 ft. wide and varied in length, in multiples of 8 ft. from 24 to 40 ft., being built in bays 8 ft. square. The deepest crib was about 30 ft. below the original low water level.

The openings between the cribs were closed with stop logs, and in front of them were placed two rows of 2-in. timber sheeting, breaking joints. The careful placing of this sheeting is largely responsible for the remarkable tightness of the cofferdam. The separate planks were driven to the bottom, rammed slightly, and on being drawn up showed by the bruising of the ends how they were to be cut to fit the rock bottom. After being shaped they were again put in place and rammed, and withdrawn a second time to determine whether further fitting was necessary. Against the sheeting was thrown the strippings from the excavations for the dam and power house, a mixture of sand and loam, and on top of this a quantity of rip-rap.

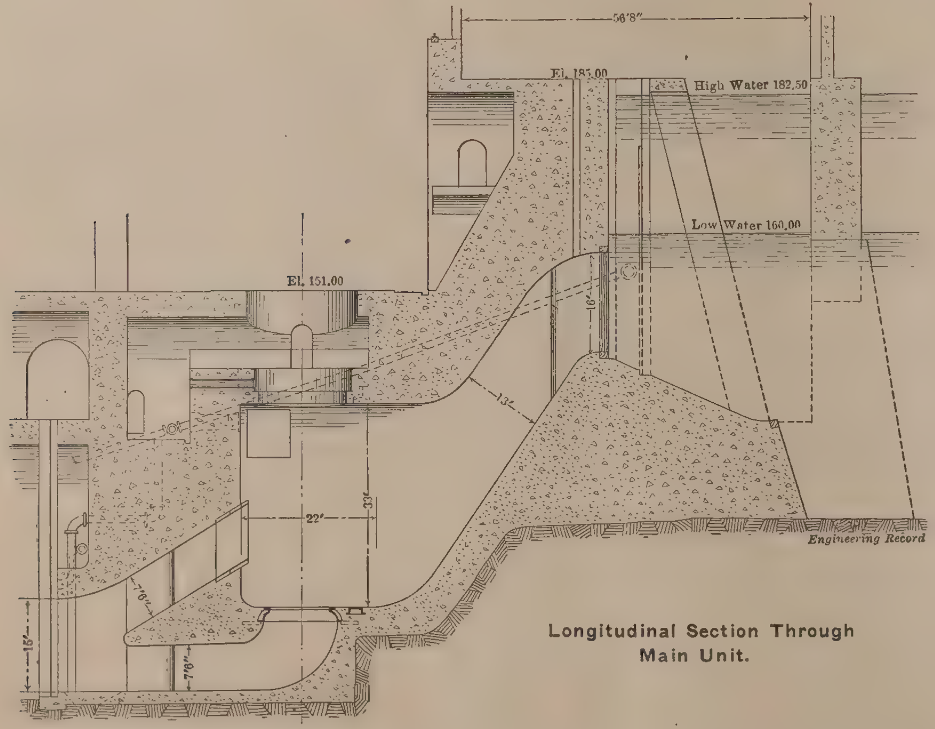
As soon as the cofferdam was sealed the dam site drained of itself. In order to determine the tightness of the work, the leakage was measured over a weir. The results were remarkable, for though there was a head of 22 ft. on the cofferdam for the greater part of its length of 1,000 ft., and the rock foundation was fissured and eroded, the leakage was only 1 gal. per second, at the present time after being overtopped by numerous floods the leakage is carried away by a 6-in. pipe.



Section Through Power House.



CROSS SECTION THROUGH C.L. OF CONDUITS

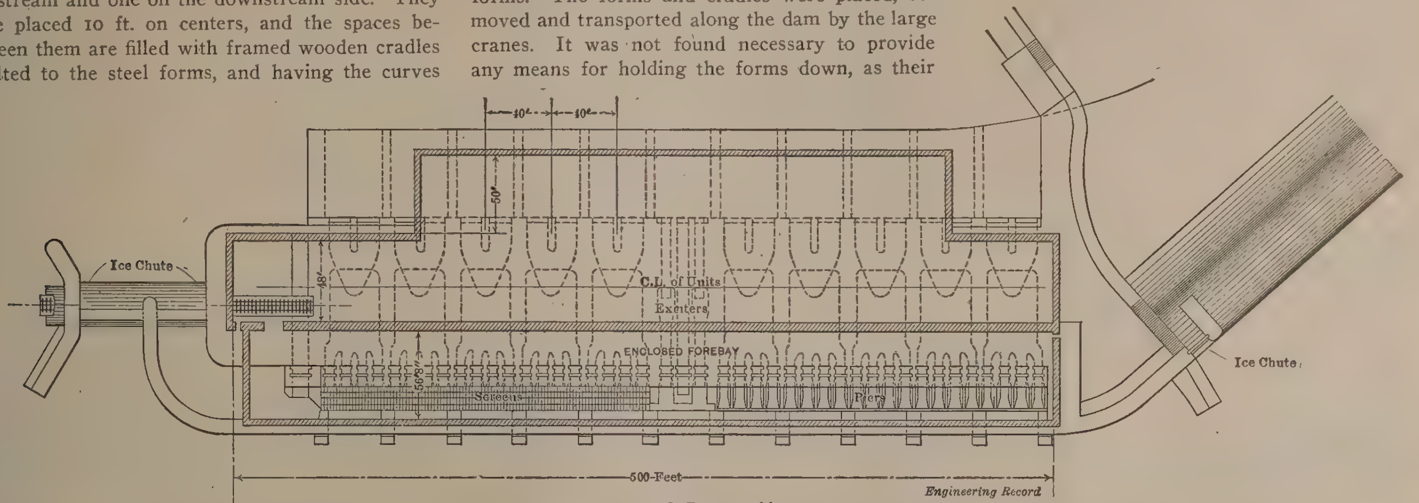


Longitudinal Section Through Main Unit.

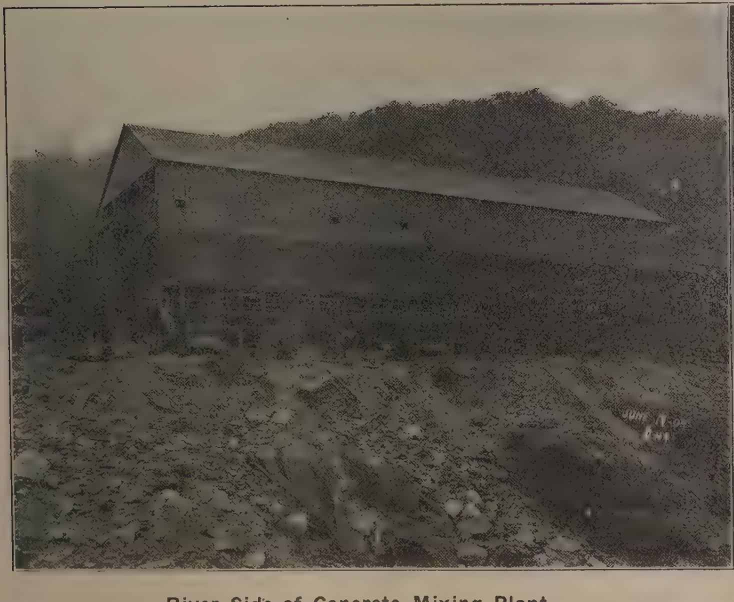
Foundation.—It was found that the rock bottom for the foundation of the power house was of the same hard gneiss which had been examined, before the work commenced, on the banks of the river and the islands near the proposed site. Near the western end of the power house, howver, the rock became more dense, contained less mica, and finally merged into a very hard and dense trap, quite similar to that quarried at Conowingo, and used in the concrete and for pudding stones. Examination showed it to be a dike which ran to Fry Island and then disappeared. Both the trap and gneiss were excellent foundations for the heavy structures and test holes drilled the whole length of the work showed the same high quality of rock for a depth of 40 ft. below the river bed. The surface rock which was considerably eroded and fissured was removed, and at the shore end of the power house about 50,000 cu. yd. of the solid rock had to be taken out. The surface of the rock was then thoroughly cleaned, and a layer of cement grout spread over it preliminary to placing the concrete. The amount placed at any one time was governed by the strength of the forms, very close supervision being given so as to guard against bulging. The bond between successive sections is secured by inbedding pudding stones in the surface of the work which is to be left to set. When the next course is added, the surface is first thoroughly swept with wire brushes, and then washed. Cement grout is spread over the surface, and the concrete work continued.

Forms.—The forms for the turbine intakes, and chambers, and draft tubes are quite complicated as everything is built of plain concrete. The forms are carefully designed and built by experienced form builders. Those that can be transported are put together on a framing platform adjoining the carpenter shop, and are carried to the work on flat cars, and set in place by means of cranes. In order to fashion the complicated curves on many of the forms, sheet iron and bass wood are used, the latter being bent into shape after being steamed. The forms are very heavily braced and tied across when possible by iron rods, as any bulging or displacement would result in altering the carefully designed water passages, and cause a loss of head by obstructing or changing the course of the flowing water.

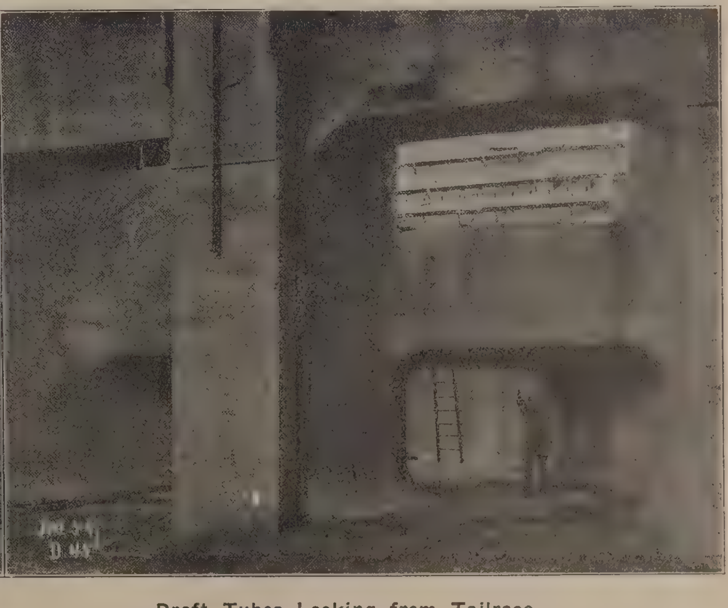
The forms used on the dam are deserving of special attention and represent one of many instances on this work of the skillful design of construction equipment. Unlike the general run of large contracting plants which contain many makeshifts built primarily for some other class of work, much of the equipment here is of original design, and well adapted for the work. The entire method of construction and the means for carrying it on show a well considered plan which was fully determined before the work was started. The length of the pier sections of the dam correspond with the most efficient working capacity of the bridge cranes, and the spacing of the structural steel forms, has likewise been fitted to these cranes so as to profit by their full capacity.



Plan of Power House.



River Side of Concrete Mixing Plant.



Draft Tubes Looking from Tailrace.

The forms for the dam consist of structural steel bracing completely spanning the section of the dam, and resting on two shoes, one on the upstream and one on the downstream side. They are placed 10 ft. on centers, and the spaces between them are filled with framed wooden cradles bolted to the steel forms, and having the curves of the surface of the dam. The steel forms consist of a post with a total height of 57 ft. supporting a rafter which runs over the apron, and rests on a shoe at a horizontal distance of 68 ft. 2⅞ in. from the shoe under the post. Beneath the inclined rafter is carried a 12-in. 20½-lb. channel having the exact curve of the apron. On the bottom of the chanel is a 2-in. timber, bolted to it, and having a width of 1 ft. 9½ in. Bolted to this strip are uprights 3 in. wide and 6 in. high on each side, having bolt holes through them by which the cradles are fastened between the steel frames. The cradles are each 8 ft. 2⅜ in. long and 4 ft. 2¾ in. wide, and each one is numbered according to an erecting diagram, for its proper place on the dam. On the channel sections the dam is being built in 40-ft. piers, with 40-ft. openings between them. For these piers five of the steel forms were used and braced together by diagonals, and by a large box beam connecting the forms above the crest of the dam. At the shore of Fry Island, where the section was changed, the steel forms could not be used because of the warped surface connecting the sections. Wooden-braced forms were therefore put in place and the value of the steel forms was demonstrated by the difficulty experienced at this point. The steel forms were used on the island section by merely unbolting the rafter at the center and allowing the two parts to overlap and pass each other, the lower part of the apron having the same curve on both sections, thus obviating the necessity of having two distinct sets of forms. The forms and cradles were placed, removed and transported along the dam by the large cranes. It was not found necessary to provide any means for holding the forms down, as their weight alone was sufficient, but wires were passed through the dam, tying the vertical post and the rafter together to prevent the latter from bulging. An additional advantage of the steel forms lies in the saving in instrument work, it being necessary to set only the shoes with transit and level.

The cofferdam in the York channel is now completed and sealed, the flow being diverted through the openings between the pier sections of the dam across the Lancaster channel. The remainder of the dam will be built behind the new cofferdam and carried up in the manner followed with the Lancaster section, leaving 40-ft. openings. These openings will then be closed alternately in the two channels by stop logs and the concrete carried up behind them, the flow being diverted alternately to the two channels.

Construction Bridge.—The method of carrying the materials to their places in the power house and dam is decidedly novel, and has proven economical and satisfactory. Before work was started on either structure a plain concrete bridge 1,060 ft. long and 50 ft. wide, containing 16,000 cu. yd., was built across the Lancaster channel to Fry Island, parallel to and 16 ft. from the downstream edges of the dam and power house. The York Channel now being closed by the coffer dam, the bridge is being extended across it, making the total length about 2,300 ft. The arches of the bridge immediately in back of the openings between the pier section of the dam have the same span as that opening, 40 ft., so as to discharge readily all the water coming through the openings. Back of the piers, however, and alternating with the 40-ft. arches are 32-ft. arches, the discharge through them not having as high a velocity as that coming unchecked through the larger openings. The arches back of the power house have spans of 35 ft., this being the width of the draft-tube discharge passages into the tail race. This end of the bridge is to be part of the permanent construction and will serve as the foundation for the transformer house. The disposition of the remainder of the bridge has not yet been determined.

Cranes.—On the bridge are laid four standard gauge tracks, and spanning them with a gauge of 44 ft. are three large traveling cranes. The clearance under the latter is 16 ft. 3 in., so that cars and engines can pass beneath them. Each crane has four outriggers with a horizontal reach of 94 ft. and a capacity of 5,000 lb. at the end of each outrigger. The carriages are operated independently of each other, and each crane is consequently the equal of four separate cranes, each with a capacity of 5,000 lb. The outriggers extend out beyond the upstream face of the dam and can deliver buckets, pudding stones, forms and necessary materials to any part of the work. The carriages run down over the tracks beneath the cranes and take the materials direct from the cars. The outriggers are spaced 10 ft. on centers to agree with the spacing of the steel forms and thus are enabled to deposit four buckets of concrete or place four pudding stones at a time. They are moved along the bridge by the dinky locomotives. The hoisting engines for the carriages are operated by compressed air, supplied from the main compressor plant.

The cranes on the bridge are used in placing materials in the power house as well as in the dam, but for building the former two additional cranes of special design are used. They consist of a tower 125 ft. high running on a track with a gauge of 45 ft. and carrying outriggers hinged 90 ft. above the top of rail. Each tower has two outriggers 135 ft. long with a capacity of 5,000 lb. each at the end, and since these can be carried horizontal as well as at an angle with the horizontal, the maximum reach is equal to the length of the outrigger. These cranes are placed on the upstream side of the power house, and the outriggers extending across to the tracks on the construction bridge, handle materials from the downstream side of the structure. As in the case of the cranes on the bridge they were designed especially for the construction of this plant.

Concrete Mixing Plant.—The concrete mixing plant is placed on the Lancaster shore, near the beginning of the construction bridge. It is 200 ft. long and 90 ft. wide, divided longitudinally into four rows of bins, over each of which runs a standard gauge track. These bins which are 16 ft. deep are divided into smaller compartments by partitions 12 ft. apart. Three of the bins are used for storing stone, and the fourth for sand, while the cement is kept in a bay 25 ft. 8 in. wide running the entire length of the building, and served by a special track outside the plant. The passage of the various ingredients through the building is entirely by gravity. Beneath the bins and across the width of the plant directly under the discharge gates run tracks of 3-ft. gauge, on which the charging cars are operated. These cars are of the bottom-dump type, and run to hoppers which discharge into the mixers. The latter, of which there are eight, are placed 25 ft. on centers, and dump into 1-yd. buckets carried on flat cars on standard gauge tracks which lead to the construction bridge.

The materials are brought into the mixer plant in standard bottom-dump gondolas with a capacity of 100,000 lb. each, and unloaded into the bins. Charging cars having a capacity of 1 cu. yd. each are run successively under the discharge gates of the cement, sand and stone bins, and then carry the aggregate to chutes leading to the mixers. The discharge openings of the bins are closed with sheet steel sliding gates operated by compressed air. A rod connected with the piston of an air cylinder runs beneath each transverse row of bins and slides through U-bolts fastened to the under side of the sliding gates. When it is desired to secure a charge from a bin a pin is slipped through a hole in the rod immediately in front of the U-bolt of the door to be operated. Compressed air is admitted to the proper end of the cylinder and the door is opened. Closing is effected by slipping the pin in a hole in the rod on the opposite side of the U-bolt, and admitting the air to the opposite end of the cylinder. There are two narrow gauge tracks to each mixer, parallel to each other and served by a distinct transverse row of bins, so that while the car on one track is discharging into the mixer, the car on the other track is being charged with the ingredients for the next batch. The charging cars have been divided into two unequal compartments, one of which holds the proper amount of sand and cement for a batch and the other the proper amount of stone. Steam-driven Smith mixers with a capacity of 1 cu. yd. each are used.

The plant has a capacity of 2,400 cu. yd. in 10 hours. The storage capacity is about 5,700 cu. yd. of stone, 1,100 cu. yd. of sand, and, together with an auxiliary storage house, 70,000 bbl. of cement.

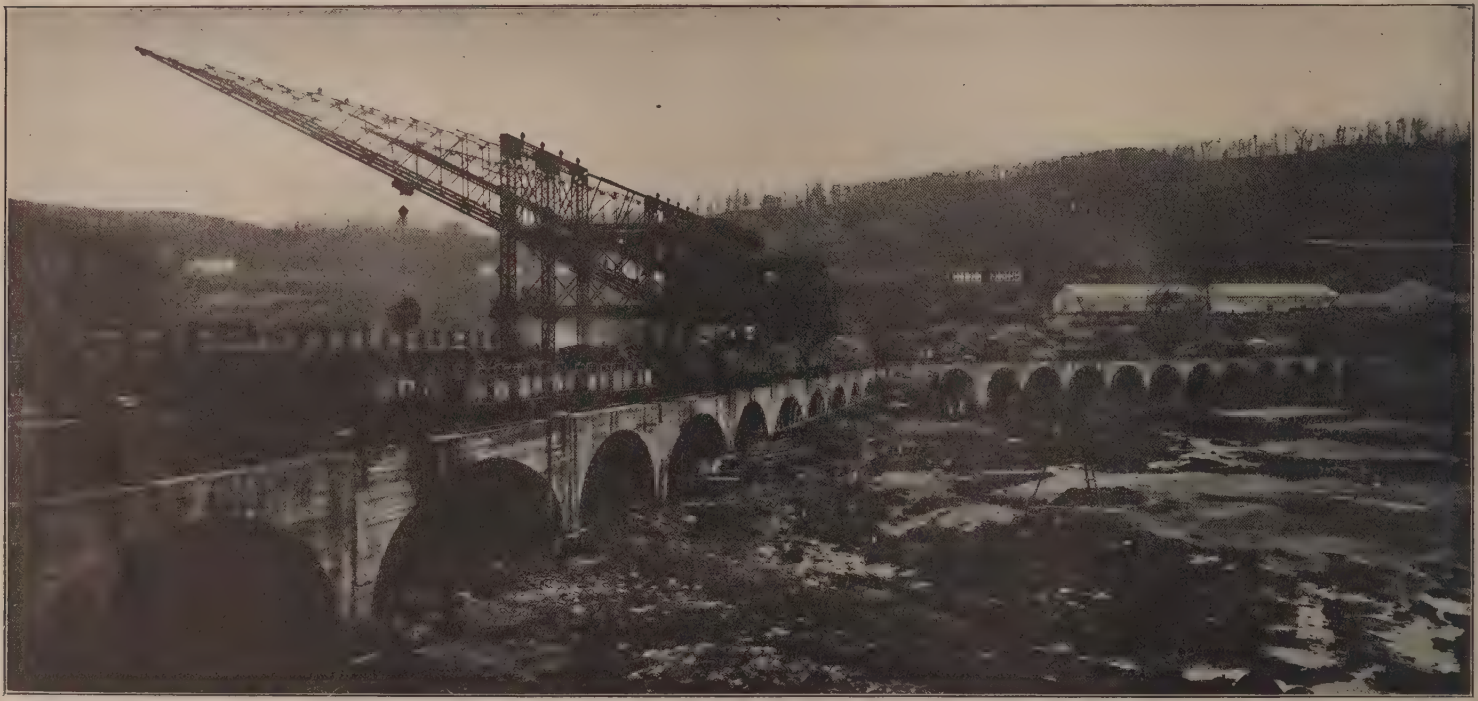
The track in front of the mixers runs directly to the construction bridge, and has a switch to an outer track at the end of the plant away from the bridge so that an engine bringing in a string of empty buckets, does not have to set them out on a siding in order to pull out the train of loaded cars. Should it be pushing the empties, it runs on the outside track beyond the mixng plant, then takes the switch to the track in front of the mixers, and pushes out the loaded cars. In pulling empties from the bridge, the dinky pushes out the loaded cars, and drops the empties in passing the mixers.

Auxiliary Plant.—The auxiliary plant connected with the work embraces a power house, machine shop and carpenter shop. The power house contains two Sullivan compressor outfits, with a capacity of 600 h.-p. supplying 3,800 cu. ft. of air per minute at a pressure of 100 lb. per square inch. The plant and camp are lighted by electricity, the current being furnished by a G. E. alternator. Steam for the engines and for heating the camp is supplied by four 150-h.-p. Atlas boilers. The machine shop contains 5 forges, a steam hammer, two engine lathes, two drill presses, two punches, a shaper and some smaller machines. The carpenter shop contains a swinging crosscut, a circular and a band saw. The augers used both in the shop and in the field are driven by compressed air. A number of small saw mills were used in cutting up the timber which originally covered the hills on both sides of the river, the timber for the cofferdams being all secured from this source.

Five standard flat cars are used on the work, 55 concrete cars carrying two 1-yd. buckets each, 16 mixer charging cars, twenty-five 6-yd. dump cars, 4 dinky standard-gauge locomotives, one 45-ton Baldwin yard engine, 4 narrow-gauge dinkies with a supply of 4-yd. narrow-gauge dump cars, 25 Ingersoll compressed air drills, 12 traveling derricks and one 12-in. and two 20-in. Morris centrifugal pumps. The concrete cars were all built on the work, the dump cars by the Western Dump Car Co., and the traveling derricks by the American Hoist & Derrick Co.

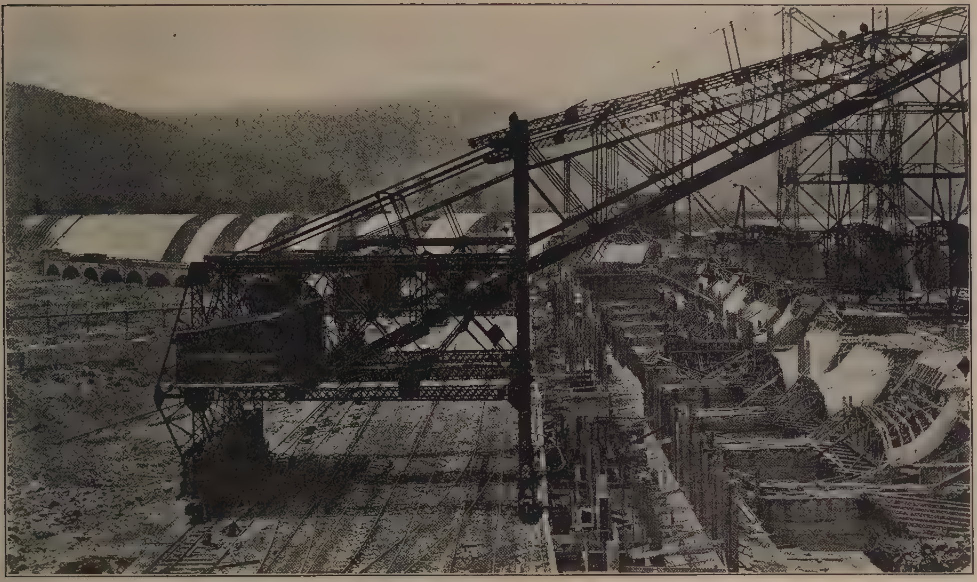
The amount of freight coming to the plant, about 50 cars per day, consisting of supplies, equipment, and construction materials has resulted in the running of a special freight train every day by the Pennsylvania R. R. to handle the business. The tracks in the power company's yard are well maintained with the result that there has never been a derailment.

Quarry.—The quarry at Conowingo, Md., is equipped with four 7-ton Lidgerwood cableways, each with a span of 550 ft. across Conowingo Creek. Rock is being taken from both sides of the stream for a stretch of 1,000 ft., the cable-



Looking toward Lancaster Shore Showing Dry River Bed, Construction Bridge and Plant.

ways being mounted on tracks so that they can be moved to cover all parts of the work. The rock is hoisted by the cableways in skips and put into dump cars for transportation to the crushing plant, or into 50-ton gondolas for delivery to McCall Ferry. Six 10-ton traveling derricks are used in handling the material immediately alongside the railroad tracks. Thirteen Ingersoll-Rand, 15 Little Jap, and 4 Little Wonder drills, the latter made by the Hardsocg Wonder Drill Co., are being used. There are in use 3 dinky locomotives, one 45-ton Baldwin yard engine, twelve 12-yd. dump cars, six 7-yd. dump cars, and two No. 8 Austin gyratory crushers.



Dam, Power House and Large Crane, McCall Ferry Plant.

Miscellaneous.—The backing-up of the water by the dam will flood the present right of way of the Pennsylvania R. R., and the power company is therefore building a new line for the railroad, 13 miles long, at an elevation from 20 to 30 ft. higher than the present grade. This work is being done under contract by H. S. Kerbaugh, Inc.

When the work was started there were no accommodations at McCall Ferry or in the neighborhood for the large force required in building the plant. The company, therefore, built a camp and installed a steam heating system, electric lights, running water in all buildings, and sewerage and fire protection systems. About 1,500 men are employed, 400 of them being at the quarry at Conowingo.

The total yardage of concrete including pudding stones, in the power house, dam and construction bridge will be 330,000, about half of which has now been placed. The total rock excavation amounts to 200,000 cu. yd. The cost of the entire plant including property and the new line for the Pennsylvania R. R. will be $10,000,000.

The work is being done by day labor. The New Jersey Bridge Co. built the bridge cranes and the steel forms for the dam, and the Baltimore Bridge Co. the tower cranes.

Dr. Cary T. Hutchinson is chief engineer of the McCall Ferry Power Co., and Mr. Wm. Barclay Parsons is consulting engineer. Mr. Hugh L. Cooper is the hydraulic engineer and designed and is constructing the hydraulic plant on an administration basis and no work is being contracted. Mr. B. R. Value is the engineer in charge of construction.

RAILROAD TIES for use on the lines of the Italian state railways will in future be preserved by the Rueping process. The government recently entered into a contract with the owners of this preservative process whereby all of the ties are to be treated.

Cost-Keeping as an Aid in Managing Men

Engineers are better qualified to act as managers of large enterprises to-day than they were formerly, owing to the development of cost-keeping and cost analysis, according to a paper on cost-keeping as an aid in managing men, recently published in the "Proceedings" of the Pacific Northwest Society of Engineers. The author, Mr. Halbert P. Gillette, chief engineer of the Washington Railroad Commission, first points out that before the development of methods of cost-analysis, the successful manager of men was usually one who relied mainly on his knowledge of human nature and his ability to hold men to his tasks. They were drivers, and only men willing to play such a role were successful as a rule. Of late years, however, engineers have been rising to the head of one undertaking after another, who have generally achieved their success through ability to get at the cost of each kind of work and study methods of reducing the expense of each item.

Natural Tailrace Channel and Mixer Plant, McCall Ferry Plant.

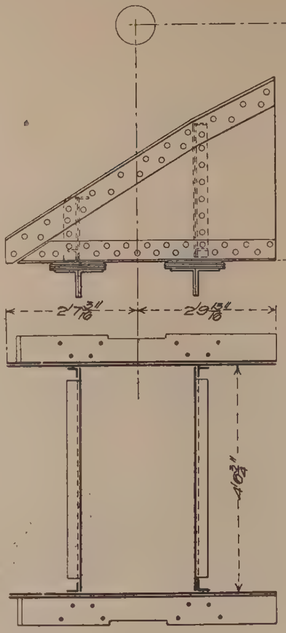
To most people, a cost-keeping system means nothing but a sort of bookkeeping, and they are unable to understand how a bookkeeper can develop into a successful manager. But the truth is that modern cost-keeping involves cost analysis, and cost analysis involves a study and comparison of the relative economy of men and of machines, and a study of relative economy leads to improvements, both in machines and the methods of using them. Cost-keeping has for its main object the determination of the efficiency of men. A proper system of cost-keeping tells daily what each workman or each gang of workmen has accomplished. It is better than a foreman, for it cannot "stand in" with the men. It is better than a foreman, for it costs you less and it tells more. A cost-keeping system tells who are good men and who are lazy men. It shows whom to discharge and whom to promote. It tells whose wages are too high and whose are not high enough. And, finally, it leads to that ideal condition of industrial organization known as profit-sharing. When a manager has learned, by cost-keeping, that certain men or groups of men produce more than others, he soon perceives that the advantage of stimulating them to further use of brain and muscle by paying them a bonus for each unit produced in excess of a prescribed minimum. The men respond to this stimulus, and often in a remarkable degree.

A proper system of cost-keeping shows the material used and the labor performed every working day. The day is the unit of pay for work done, and it must be made the unit in measuring work wherever the work is of such nature as to permit daily measurement. Often it is not practicable to make accurate daily measurements of work accomplished. Then it is usually possible to estimate the output approximately. For example, to measure the yardage of concrete placed in a day may not be readily done, but the number of sacks of cement used each day can be recorded, and the yardage of concrete thus estimated closely. It is in devising methods of approximating the output that an engineer has a chance to use his ingenuity and his engineering knowledge.

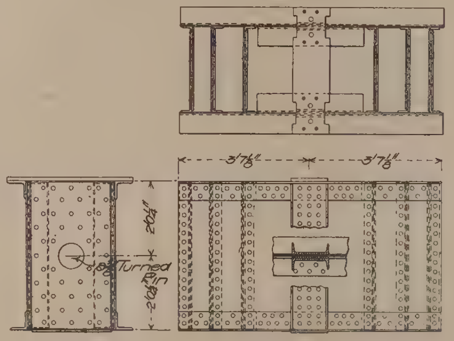
Second only in importance to securing records of work done is the devising of ways that enable the manager quickly to compare results day by day. All engineers have been trained to depict mechanical measurements and formulas graphically by the aid of charts, diagrams and curves. Hence it is second nature for the engineer to plot a "cost curve," which shows at a glance the unit cost of each kind of work for each day or each week. When a marked fluctuation occurs in the cost curve, indicating a rise or fall in the unit cost, then it is that the manager can usually visit the work to advantage. His very coming at such a time is in itself a spur to the men, for they realize that he is keeping in constant touch with their progress, and immediately notices an increase or decrease in output.

By the modern method the contractor receives a daily report of work done at every cut. In rock the report shows the number of linear feet of holes drilled, the pounds of explosive used, a chart of the location and depth of drill holes, carloads of rock hauled away, and such other details as are needed to determine both progress and economy of work done. Instead of the old progress profile, he has a mass diagram which indicated the total number of cubic yards in each cut, or in each group of cuts. On this mass diagram the amount of material removed each day is indicated, and, since the diagram is drawn to scale, the areas show at a glance the total work to be done, the amount done to date, and the amount remaining to be done. On a large mass diagram of the whole excavation it is well to indicate the points that should be reached at the end of each week, if the contract is to be finished within the time limit. Similar mass diagrams show the yardage of masonry and other diagrams are prepared for the quantities of other items in the contract.

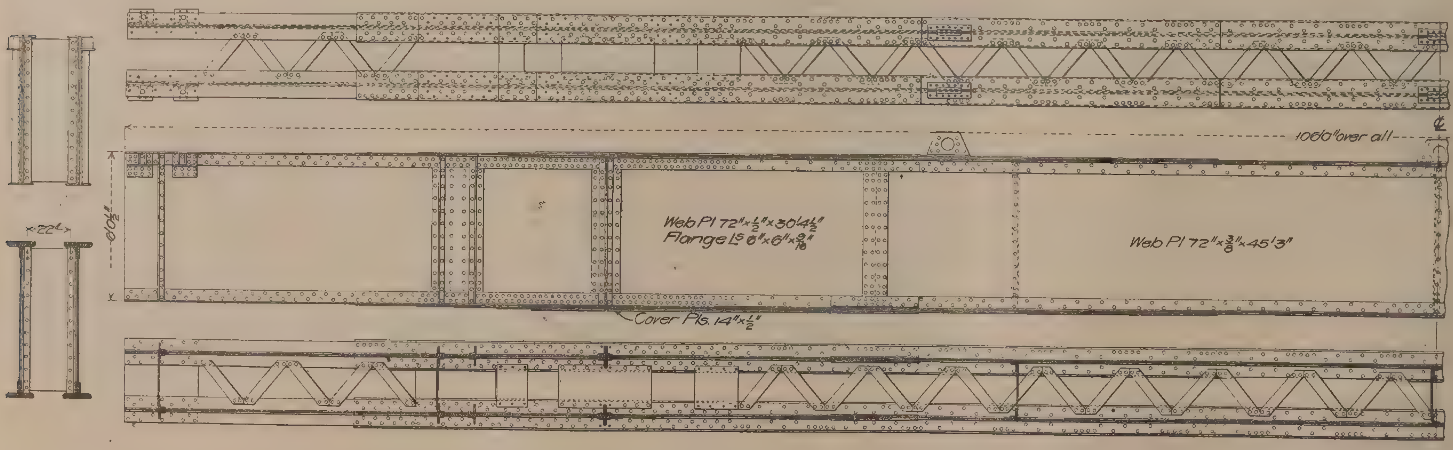
Diagrams of this character possess two decided advantages over the tabulated reports from which they are prepared: First, they permit of quick comparisons of progress by days, by weeks and by months. Second, they insure that no reports are omitted or sent in incomplete. It is easy to overlook the omission of a certain daily report, when examining a pile of such reports, but on a diagram no such omission is possible.



Filler between Inclined Chord and Bottom Girder, Quebec Bridge.



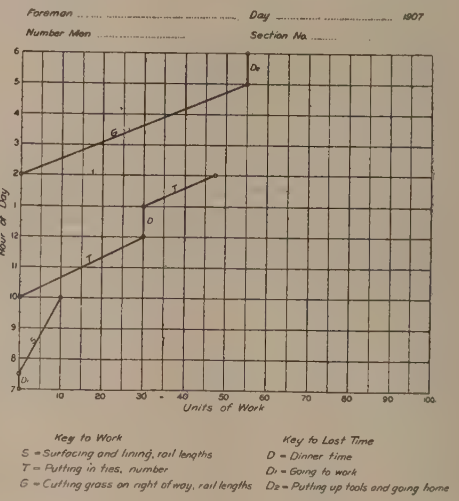
Bearing Girder under Bottom Girder, Quebec Bridge.



Tranverse Bottom Girder Suspended from Cantilever to Carry Falsework, Quebec Bridge.

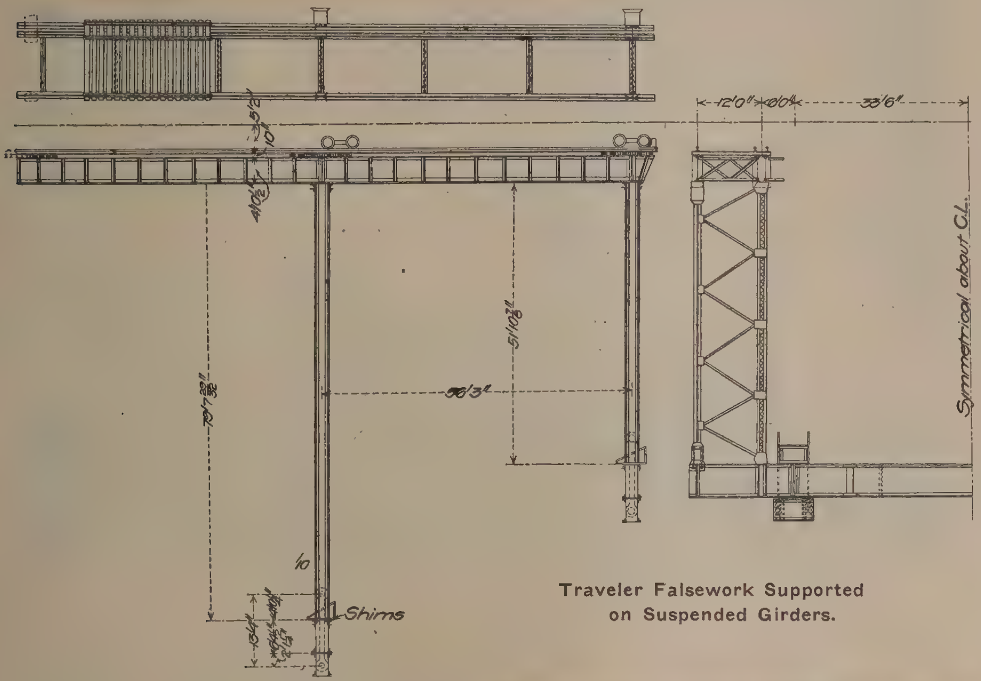
In the prosecution of my present work of appraising the value of the railways of the State of Washington, I have gone through innumerable records of the cost of bridges, culverts and other structures. It has been noteworthy that the cost of a very large percentage of structures has exceeded the engineer's estimates; and, in such cases, the engineer, or the superintendent, tries to explain the cause of the excess cost. The records show, in most cases, that neither of them knew what the cause was until after the work was finished. No better example could be found of the inefficiency resulting from a lack of the use of modern methods of cost-keeping. Indeed, I may go a step farther and say that practically all the railroads of our country are poorly managed in nearly every department, simply because they cling to out-of-date methods of cost-keeping. Usually, however, they pride themselves upon the completeness of their records, but, as compared with the methods of cost-keeping used by up-to-date manufacturers and contractors, the average railroad is in the kindergarten class. Occasionally you will find a division superintendent who has charts made showing the daily movement of freight trains over a division. But I know contractors who have similar charts made every day which show the movement of every wagon load to the nearest five minutes of time. They can tell you not only the distance traveled and the number of trips made by each wagon, but each delay and the cause thereof. Surely if it pays to watch the movement of wagons with such care, it will pay to watch the movements of trains in a similar manner, and to study and compare results with even greater care. Yet, so far as I can learn, the details of train movement are not ordinarily plotted and studied with anything like the minuteness which a cost-analysis engineer employs in managing the movement of dirt trains over a narrow gauge temporary track.

For the purpose of indicating the degree of refinement of cost-keeping which certain contractors employ, I present herewith a diagram which is susceptible of wide application. It is like the log of a ship, in that it shows the events of each day and the progress from hour to hour. The diagram, or form, is a proposed card to be used by section foremen, and it shows the day's work done by a gang of section men. The vertical lines, or ordinates, show the hours of the day from 7 A. M. to 6 P. M. and the intermediate quarter hours. The horizontal lines, or abscissas, show number of units of work accomplished. The black circles are holes punched with a conductor's punch. The lines connecting the punch holes can be ruled in after the day's work is done. This particular card shows that the gang of men arrived at the site of the day's work and started in at 7.30 A. M. At 10 A. M. they had completed 10 units of work, and the key letter *S* on the straight line between 7.30 and 10 A. M. is found to be the number of rail lengths of track surfaced and lined. At 10 A. M. the gang began putting in ties, as is indicated by the key letter *T* on the straight line between 10 A. M. and 12 M. Then the curve of work rises vertically from 12 M. to 1 P. M., indicating that no work was done during the noon hour. From 1 to 2 P. M. the work of putting in ties was continued. At 2 P. M. the gang began cutting grass, as is indicated by the key letter *G*, and quit at 5 P. M., having cut grass for a distance of 55 rail lengths. Then the curve of work rises vertically from 5 to 6 P. M., and the key letter *D* shows that this hour was lost in picking up tools and going home.



Section-Gang Work Chart.

It will be noted that a card of this sort gives a perfect log of the day's work, showing all delays, their cause and duration, and number of units of work accomplished. On the back of the card a series of key letters should be printed so that the foreman can indicate on the curve of work any kind of work done, and the units in which it is measured. The rail length is a convenient unit for certain classes of work, the distance between telegraph poles may serve for other classes. Incidentally all telegraph poles on each section should be numbered consecutively. Then the foremen can be required to report the exact location of the work by writing the number of the pole on the curve of work diagram. With a system of this sort, and by paying section foremen about 50 per cent. more than is the present practice, it would be an easy matter for any engineer to increase the average output of section men by 100 per cent. over present outputs.



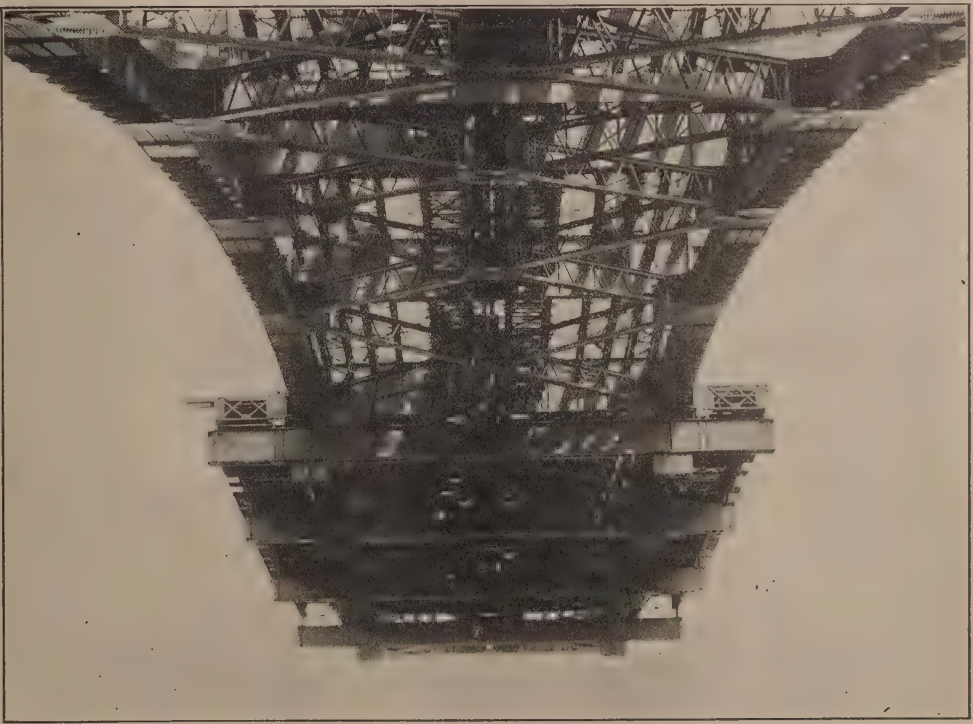
Traveler Falsework Supported on Suspended Girders.

The card shown herewith is obviously applicable to innumerable kinds of construction or manufacturing where men work as individuals or in gangs. It becomes complicated when a gang under a foreman is split up into smaller gangs which are continually shifted from one kind of work to another. But such shifting is usually unnecessary, and can be obviated, as a rule, by the use of better judgment in the management of the work. Indeed, the very objection to the use of such daily card reports points the way to better management by indicating the lack of reason for using small units that putter away time.

There is a rapidly growing demand for engineers who can devise and apply a modern cost-keeping system. Indicative of this fact Mr. Gillette stated that within the last few months he had many inquiries from very large contracting firms, as well as from engineering departments of the federal government, for names of competent cost-analysis engineers. These inquiries are coming in with increasing frequency, showing that the value of the services of a cost-analysis engineer are being recognized. Frequently, however, the salaries offered would be no inducement to an engineer having a satisfactory position; but the chances for advancement in salary is infinitely greater than in the ordinary lines of engineering professional work. Moreover, the chance to become a partner in a firm is much better where a man is engaged in studying labor costs with a view to reducing them than it is where he is engaged in studying designs with a view of saving materials. Few men are capable of judging the true worth of the engineer who saves money by an economic design of a bridge or by the economic location of a railway. But no man is so blind as not to be able to see the ability of the engineer who reduces the cost of excavating rock by 10 cents a cubic yard, or who effects an increase of 5 per cent. in the tonnage hauled over a given division. Hence, it will always be more profitable to be a cost-analysis engineer than to be a designing engineer or a locating engineer.

The Suspended Falsework of the Cantilever Arms of the Quebec Bridge.

The recent collapse of a part of the Quebec Bridge gives added interest to anything connected with the design and erection of that structure. In earlier articles concerning it attention has been called to many of the details and to the carefully developed field methods. One of the most interesting parts of the erection was the use of suspended falsework in connection with the river arm, which will be described in this article.



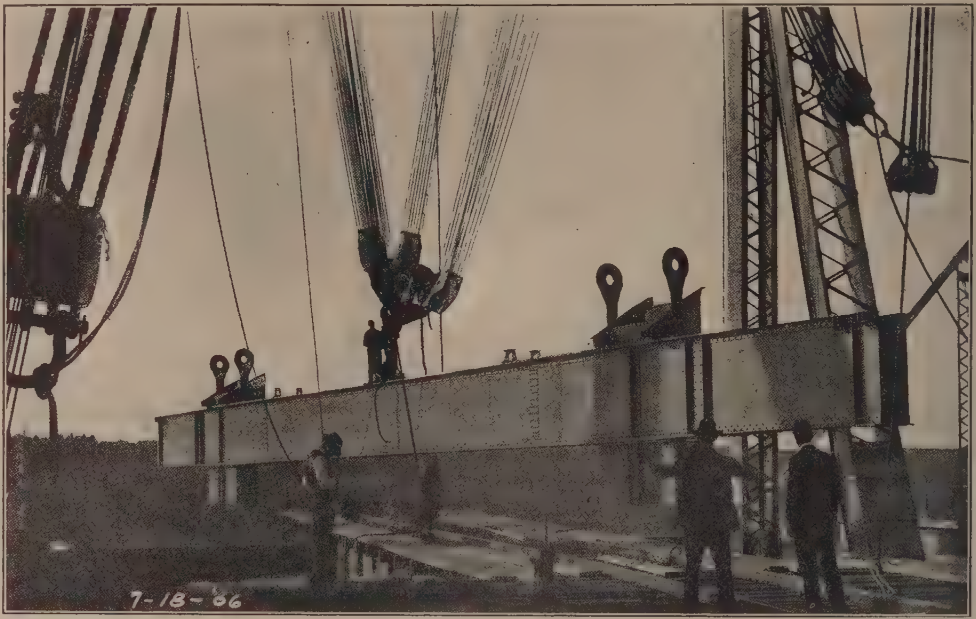
Traveler Falsework Suspended from Cantilever Arm, Looking up.

The 560-ft. cantilever arm of the Quebec Bridge had trusses 67 ft. apart on centers and 315 ft. in maximum depth erected by the same great gantry traveler which had already been used for the erection of the south anchor arm. The traveler, which was illustrated and described in The Engineering Record of March 4, 1905, weighed with its equipment about 2¼ million lb. and had a Z-shaped longitudinal elevation, with a 54x103-ft. tower, 212 ft. high and a 66-ft. forward overhead cantilever. It moved entirely outside the finished superstructure with horizontal and vertical clearances of 79 and 202 ft. respectively. It moved on two 12-ft. gauge tracks 91 ft. apart on centers, at roadway level, one track 12 ft. outside the center line of each truss. For the anchor arm these tracks were supported on two lines of steel falsework towers erected on shore between the main and abutment piers. The south cantilever arm had been and the north cantilever arm was to be erected by the cantilever method self-supporting during erection at a maximum clear height of about 150 ft. above the high water of a maximum depth of 200 ft. The support of the traveler tracks in the same manner as for the anchor arms was, of course, impossible and a system was devised of suspending them from the cantilever trusses in a novel and ingenious manner which, before it proved to be successful, was considered by some bridge engineers to be impracticable and was undoubtedly without close precedent for its magnitude and the details of its construction.

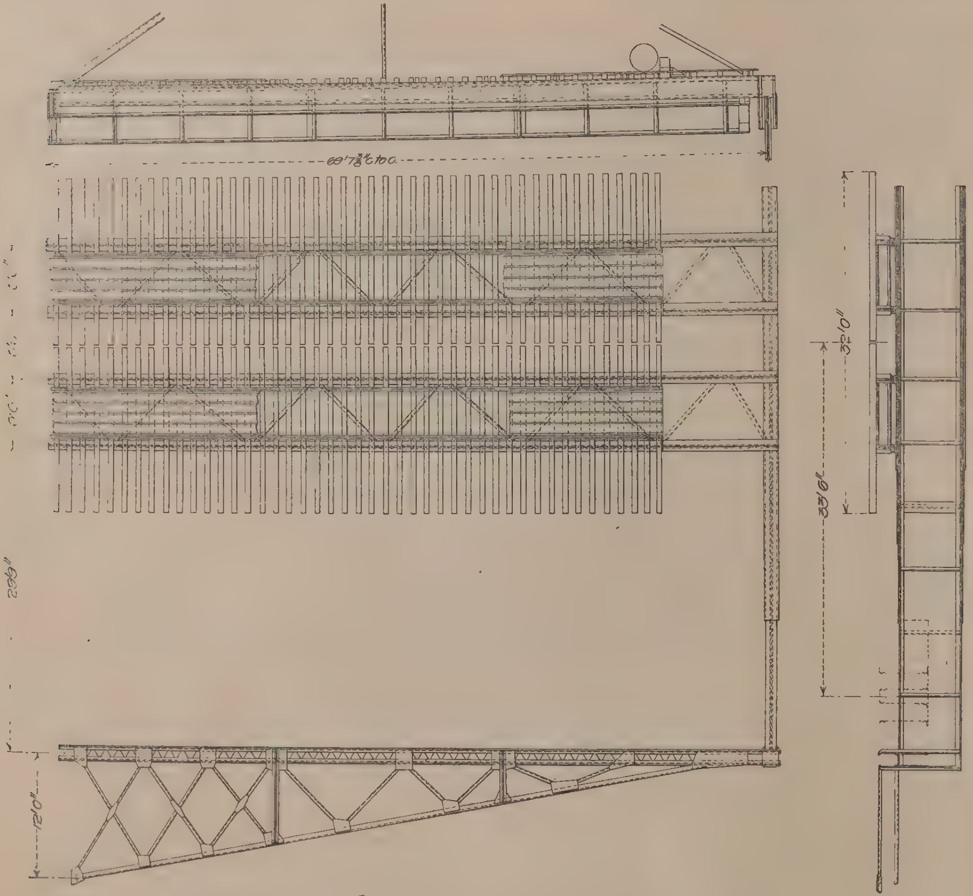
The cantilever arm falsework consisted essentially of two sectional steel viaducts, about 80 ft. in maximum height, supported on each side of the cantilever arm on the cantilever ends of box plate girders suspended from the lower chord pins of the cantilever trusses. Each viaduct was made with three lines of longitudinal girders supported on transverse bents each composed of two vertical posts 12 ft. apart on centers; the bents being spaced 56 ft. 3 in. apart longitudinally to correspond with the panel points of the cantilever trusses. The vertical bents diminished in height from the piers to the extremities of the cantilevers but the box girders supporting them were duplicates for all points so that only four of them and four full sets of longitudinal girders were required. This provided one panel more than was necessary for the support of the traveler and permitted the removal of the rear panel and its re-erection in front, panel by panel, as fast as the traveler progressed. The total weight of the cantilever arm falsework was about 200,000 lb. exclusive of permanent track stringers utilized and the box girders, the heaviest members, weighed about 25,000 lb. each. All members were handled by tackles swung from the completed portion of the cantilever arm or from the traveler itself and after the erection was well advanced the rear panel falsework could be removed and replaced in front ready for the traveler to be moved forward on it in a short time.

The suspended box girders were 106 ft. long, 6 ft. deep and 42 in. wide over all. Each girder had two 72x½-in. webs, 28 in. apart made in three shop-spliced sections, eight 6x6x9-16-in. full length flange angles and on each flange four 14x½-in. cover plates varying in length from 29 to about 87 ft. The webs were connected by five transverse vertical shop riveted diaphragms and both top and bottom flanges were connected by side plates and lattice bars as indicated in the general drawings.

Three sets of connections were temporarily bolted to the top flanges to provide for the attachment of the hoisting tackles by which the girders were handled. Each set consisted of a pair of short 12-in. channels with their vertical webs riveted together and bored to receive a 6-in. horizontal pin with its axis parallel to that of the bridge. The lower flanges were secured to the top flanges of the beam by 14 turned bolts through each and the connection resembles a simple shoe to receive the end bearing of a small truss. In the planes of the cantilever trusses and of the vertical posts in the falsework bents the plate girder webs were stiffened by vertical reinforcement angles and filler plates proportioned to receive the maximum vertical shear at these points.


7-18-06

Handling 106-Foot Bottom Girder to Support Suspended Falsework.



Cantilever Truss and Working Platform of Main Traveler,

To support the cross girder at any required panel point of the cantilever truss an eye-bar about 13 ft. long was engaged on each end of each lower chord pin and passing down between the webs of the girder, engaged a parallel pin through three vertical diaphragms, parallel to the bridge axis, which connected the web of a special bearing girder fitted to the bottom flange of the main girder at its intersection with each plane of the cantilever trusses. Each bearing girder was about 7 ft. long and 4 ft. deep with two webs 28 in. apart connected by six diaphragms 1¼ in. thick. The center of each web was reinforced by two 12-in. channels and two 12x½-in. vertical plates. In order to insure the proper position of the bearing girder under the transverse girder, a plate was riveted across the flanges of the former and engaged a slot in the flanges of the latter.

Riveted triangular filler blocks were seated on the top flanges of the main girders under the panel points of the lower chords and were wedged up to close bearing against the bottom flanges of the latter by means of tapered shim plates between them and the girders. These fillers were made with two ⅜-in. web plates about 4½ ft. apart parallel to the bridge axis and have single 6x6x½-in. flange angles on the outsides of their webs on the horizontal and inclined edges. The webs were connected by two ⅜-in. vertical transverse diaphragm plates and both upper and lower flange angles had open holes for turned bolts connecting them to the bottom flange of the lower chord and the top flange of the girders. The inclined top flange angles were slightly bent to enable them to conform exactly to both adjacent sections of the lower chord. In erection the bearing girders were permanently bolted to the main girder and the eye-bar suspenders were permanently connected to the former, the filler pieces being changed every time the transverse girders were moved, to correspond with the varying inclinations of the bottom chord.

The transverse trestle bent for each traveler track consisted of two vertical posts 12 ft. apart transverse to the bridge axis, braced with zigzag angles. The inside post carried a much heavier load than the outside post and had a rectangular cross section made with two built channels latticed. The outside post had an I-shaped cross section made with a web plate and four angles. Horizontal connection angles were riveted across tie plates on the opposite flanges at the feet of the columns and received four 1⅝-in. vertical bolts about 2 ft. long with upset ends which passed through pockets and had lower nuts bearing on corresponding angles riveted to the web of the transverse girder thus firmly securing the column to it. The base plate of the inside column was bolted to the top flange of the girder with 24 short vertical bolts. Each pair of columns was handled as a separate unit by tackles suspended from the overhang of the traveler and was changed for a shorter one to correspond with the increased elevation of the transverse girder every time the latter was moved.

Each column bent carried three lines of 4-ft. 10½-in. plate girder stringers, two of which were bolted close together with pairs of separators between their webs and were centered on the outside columns. The third girder was centered on the outside column and was connected to the other two by end and intermediate vertical transverse frames and bottom flange zig-zag angles rigidly uniting the three girders so that they formed a single unit shifted from rear to front as the erection progressed by tackles suspended from the traveler. Cross ties 10 in. high, 12 in. wide and 2 in. apart in the clear were bolted with the 3 lines of rails to the top flanges of the girders and at panel points, groups of seven

10-in. I-beams were interpolated between the ties to receive the concentrated loads from the traveler tracks. The top and bottom flanges of the inside girders were connected to the vertical members of the main trusses by short horizontal braces with bolted connections and similar braces were provided at the middle points of the longest vertical columns. The stringers used for this suspended falsework were borrowed from the railroad track of the center suspended span.

In order to deliver bridge members to the tackles suspended from the overhang of the traveler during the erection of the cantilever arm, a working cantilever platform corresponding to the overhang was extended from the foot of the traveler at roadway level. A light riveted triangular longitudinal truss 69½ ft. long and 38 ft. deep with a horizontal bottom chord was bolted through its end vertical post to each outside forward column of the traveler, 79 ft. apart transversely on centers. The lower chords of these trusses were stiffened laterally by inclined horizontal outriggers braced to form with the lower chords virtually horizontal triangular trusses 12 ft. deep at the inner ends. The outer ends of the cantilever trusses are connected by a transverse plate girder 6 ft. deep with its top flange bearing across the bottom flanges of the lower chords of the cantilever trusses. The girder was suspended from the lower chord at each end by four vertical angles engaging the webs of the chords, which were made with built channels having their flange angles turned in and latticed, and riveted at their lower ends to gusset plate projecting from the webs of the girder parallel with the bridge axis.

This girder carried the outer ends of four lines of plate girder stringers 5 ft. deep and 69½ ft. long, which at the inner ends were directly connected to the permanent floor beam. These girders had drop ends seated on the top flange of the forward transverse girder and were spaced 3 ft. 3 in. and 9 ft. 9 in. both sides of the center line of the traveler to correspond with a spacing of the two material tracks which they supported. The stringers for each track were braced together in the usual manner with vertical transverse sway-brace frames and zigzag flange angles. Each track had 6x8-in. ties 16 ft. long and 16 in. apart on centers, covered between the rails with a solid floor of 4-in. longitudinal spruce planks. It was at first intended to provide 2 additional stringers midway between the outside track stringers and the cantilever trusses to support solid floors about 16 ft. wide each side of the tracks, but these were finally omitted. Rail stops solidly riveted to the stringers and braced to the end of the platform were provided for each track to prevent the possibility of material cars being pushed over the end. The pairs of stringers, with the ties, rails and bracing for each track were independent units easily connected and disconnected from the cantilever overhang and were removed and set inside the traveler tower every time the latter was moved in order to give clearance for lowering the transverse falsework girders and permanent floor members through the framework of the cantilever overhang.

Each track on the overhang was long enough to receive one freight car and the forward truck of a second, a total of 6 axle loads, which when both tracks were simultaneously loaded were limited to the dead load of car plus 12,500 lb. each, equivalent to 50,000 live load on the car. When only one track was loaded a live load of 116,000 lb. per car, equal to a live load of 29,000 lb. on each axle was allowed. These loads produced total live load reactions of 65,000 lb. at each end of the forward transverse girder where the dead load reactions are 52,560 lb. Care was taken to remove the cars from the overhang as soon as their loads were lifted from them.

The Cooling Plant for Walter Baker & Co., Ltd., Dorchester, Mass.

In The Engineering Record of April 20, 1907, the new central power plant of Walter Baker & Co., Ltd., of Dorchester, Mass., was illustrated. It is the purpose of this article to describe a new cooling plant designed by the same engineer, Mr. F. W. Dean, of Boston, for this company. This plant is interesting as embodying the most advanced ideas in refrigerating engineering, and was designed with a view not only to simplicity and ease of operation but also to high economy.

The machinery is placed in a building previously used as a power house, but vacated upon the completion of the new central power plant. This building has been remodeled by the removal of a party wall, making a machine room 66 ft. long by 44 ft. wide. A new roof with monitor gives a clear height of 21 ft. under the main roof, and 31 ft. under the monitor. A waterproof pit 7 ft. deep and irregular in shape, with an area of 1,000 sq. ft., is used for the ammonia pumps, the aqua receivers and miscellaneous piping.

At the back, adjoining and partly over the Neponset River, an addition has been erected of brick and concrete, having a roof of mill construction with monitor. The roofs of both buildings are covered with tar and gravel and copper flashing and siding.

The condenser room has a clear height of 21 ft. under the main roof and 27 ft. under the monitor. All the woodwork in the room is wire lathed and plastered while the window frames are of copper and glazed with wire glass. All iron work is protected by concrete. One-half of the condenser room is over the river, and supported on concrete piers. The floor is of concrete sloped to drain all of the condenser water to the river. The whole river side of the house is open, except for the four reinforced piers which support the roof; openings are fitted with Kinnear rolling doors 14 ft. wide by 16 ft. high.

The steam for this plant may be obtained either directly from the boiler plant of the new power house, or from the low-pressure manufacturing lines, which carry exhaust steam to the various mills.

The refrigerating machine is of the well-known Pontifex Hendricks absorption type, operated either with exhaust or reduced-pressure steam.

The present plant is designed to cool 846 gal. of calcium chloride brine of a specific gravity 1.240 from 0° Fahr. to —10° Fahr., or each of the three units installed is capable of cooling 282 gal. of brine through a ten-degree range, the warmest brine never being above 0° Fahr.

The nominal rating of each unit is 100 tons of refrigeration or the total of the three, 300 tons of refrigeration in twenty-four hours. The plant has ben designed for an ultimate capacity of 600 tons of refrigeration, and all the units, piping, and other details are laid out with this in view. It consists of brine circulating, brine cooling, ammonia generating and condensing equipments, together with the water circulating and steam condensing units.

The purpose of this installation is to furnish refrigeration throughout the various mills of the company for cooling chocolate liquors and goods, and also for cooling rooms where chocolate goods are being manipulated.

There are some 30,000 lin. ft. of 2-in. galvanized pipe installed in bunker rooms, with air circulation to the various rooms where the refrigeration is required. Extensive mains run to all parts of the buildings, while specially designed equipment is used to reduce handling and save time. This is so extensive that no attempt will be made in this article to describe anything except the mechanical plant. All ammonia piping is confined to as small an area as possible and to the machine room, all such piping being directly under the eye of the engineer.

The brine circulating plant consists of two centrifugal pumps, in duplicate, each of 1,000 gal. capacity against a 100 lb. head and direct connected to a 75-h.-p. De Laval steam turbine operated condensing.

Each pump has an 8-in. suction taken from a 12-in. main brine return line from the various factories; a standpipe 12-in. in diameter and 21 ft. high takes care of all the air in the suction line, provides for expansion in the line, and insures a nearly constant head on the pumps.

There are three 8-in. pump discharge connections into a main supply header to the brine coolers, space being reserved for another pump of the same capacity. The brine from the pump is discharged into a 12-in. main distributing header, which has 6-in. branches to each cooler. An 8-in. by-pass is also provided for shunting a part of the brine around the coolers when desired. The brine coolers are of the Hendricks enclosed type, with spiral brine coils contained by a cast iron shell 45 in. in diameter and 15 ft. long, each weighing some 24,000 lb.

There are three Venturi meters, one on the supply to each cooler. These are provided with manometer tubes, so that the quantity of brine passing to each cooler may be easily noted. Thermometers are placed on the supply to and the return from each cooler, so that the temperature of the brine to and from each is obtained. Having given the temperature difference and the quantity of brine circulated to each, the amount of refrigeration, both total and that which each cooler is doing, in tons per twenty-four hours may be exactly computed.

The return from the cooler, which is also the supply to the factory, is 12 in. in diameter, and is connected into the main returns, both directly and through a brine tank. This tank is 4 ft. 6-in. in diameter and 14 ft. long, with a man-hole at the top for supplying calcium in bulk, when the charge needs to be increased or strengthened. It also serves as a reservoir for brine.

Adjacent to each cooler is its anhydrous receiver with the ammonia expansion line connection. These receivers are 18 in. in diameter and 10 ft. high, and contain cooling coils. Both cooler and receivers are provided with gauge glasses with automatic self-closing gauge cocks of the Hiller type. The insulation on both consists of Nonpareil sheet cork with hardwood lagging.

The generators, each consisting of a cast-iron shell 45 in. in diameter and 14 ft. long, have 2-in. diameter steam coils of the return-bend pattern, immersed in the aqua ammonia charge, and terminating in a 5-in. main steam supply header. The condensation from these coils is carried to a 3-in. main drip header, these headers being trapped and discharged to 7½ x 4½ x 6-in. Warren receiver pumps through a 3-in. pipe. These receiver pumps are in duplicate.

The main to the generator steam headers is 5 in. in diameter in each case, and is connected both into an 8-in. low-pressure main, and into an 8-in. high-pressure main through a 5-in. reducing valve. All reducing valves are by-passed and provided with valves, so that they may be repaired while the plant is running. A safety valve is also placed on the low side of this reducing valve in order to safeguard against excessive pressure. All the generator drips are pumped back to the boilers. The use of a separator on the main steam supply to the generator insures dry steam.

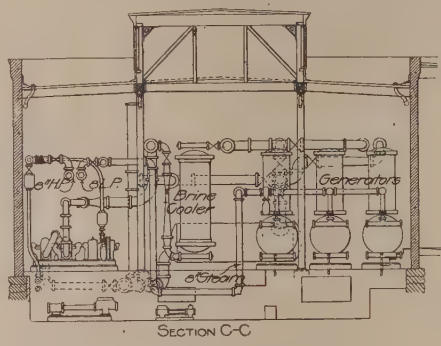
The refrigerating machines are designed to run on 5 lb. pressure during part of the year and on 20 lb. or thereabouts the remainder of the time.

The rectifier, absorber and condenser are of the atmospheric type and are contained in the condenser room on the river side of the plant. These consist of a series of vertical coils arranged side by side; the top coil is the condenser; the bottom coil the absorber, while between each 100-ton unit the rectifier is carried on pipe supports above and to one side of the condenser coil. This allows the warm water from the rectifier coils to go to waste without passing over either the condenser or absorber coils. Water distributing troughs are suspended over each vertical coil.

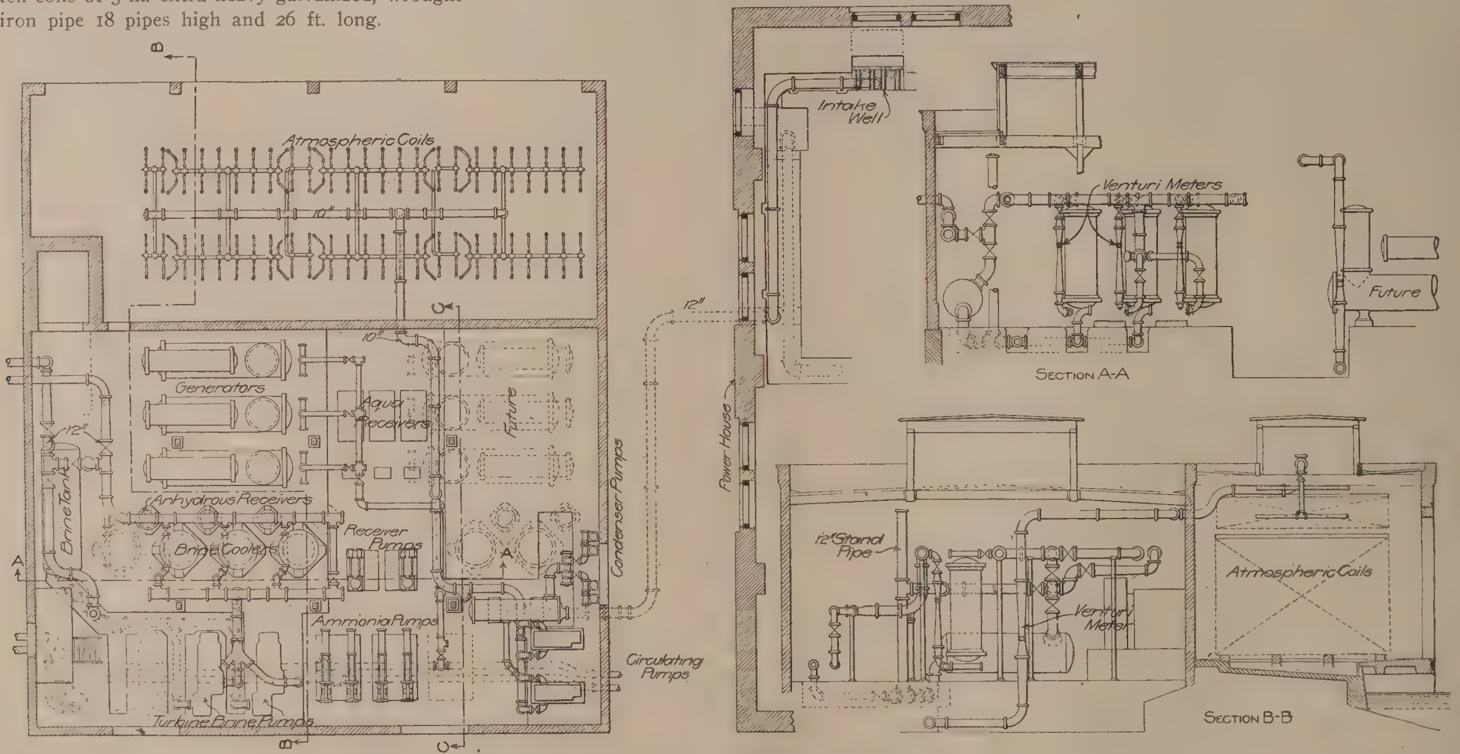
The rectifiers consist of 3-in. extra heavy galvanized pipe made into counterbored steel return bends, galvanized and fitted with gland and packing in addition to the pipe thread. These coils are 24-in. on center, ten pipes high and 26 ft. long.

The condenser consists of 2-in. extra heavy wrought iron pipe, galvanized on the outside and made into counterbored cast steel return bends, galvanized with gland and packing. Each condenser has ten coils twenty pipes high, 26 ft. long, and the condensing surface is aproximately 2,500 sq. ft.

The absorber is of the same general design as the condenser, with gas distributing pipes entering the return bends. Each absorber has ten coils of 3-in. extra heavy galvanized, wrought iron pipe 18 pipes high and 26 ft. long.



Section through Machinery Room.



Details of New Refrigerating Plant at the Works of Walter Baker & Co., Ltd.

The condensing water to the atmospheric coils is through a 10-in. main, which supplies a multitude of headers with 1¼-in. branches leading to the water-distributing troughs over the coils.

The brine cooler, the generator and anhydrous receiver are provided with special Ashton automatic ammonia relief valves with removable metal seats. The brine tank, brine mains and all piping which frost or are liable to sweat are insulated.

Except in the subway, which is constructed for about 200 ft. under a street, the brine mains are insulated with 3 in. of hair felt and canvas jacket, painted. In the subway they are insulated with 3 in. of Nonpareil cork painted with rubber cement, and the pipes are supported with special hangers outside of the insulation. The brine coolers, the anhydrous receiver, and the brine tank are insulated with 4 in. of Nonpareil cork and sheathed with hardwood lagging. The generators are covered with 2 in. of 85 per cent. magnesia and ½ in. of plastic magnesia, the whole lagged with hardwood sheathing.

The water circulating units consist of two vertical duplex Warren steam pumps, each 7½ x 7 x 12 in. for the steam condensers, and two centrifugal pumps made by the De Laval Steam Turbine Co., each of 800 gal. capacity against 30 lb. pressure for the ammonia condensers.

The turbine pumps are direct-connected to a 20-h.-p. De Laval steam turbine operated condensing. The water for condensing purposes is drawn from the Neponset River through a suction well, provided with screens and located in the basement of the large power house. A 12-in. cast iron main suction line leads from the well to a suction chamber 30 in. in diameter by 10 ft. long. All the water pumps take water from this chamber.

The atmospheric absorbers are each drained to a receiver 36 in. in diameter by 6 ft. long, and provided with gauge glass, and self-closing cocks. From the bottom of each aqua receiver suction lines are carried to the ammonia pumps. There are four such pumps, each of the Blake direct acting type, 12x6x16 in., one for each refrigerating unit and one in reserve.

The steam is condensed by two 7-in. Bulkley condensers, one for the turbine water pumps and one for the brine pumps. Not only may these pumps be run condensing, but are also cross-connected into an 8-in. low-pressure manufacturing line, and to the steam supply of the generators. This applies equally to all steam pumps.

The Bulkley condensers are located on the outside wall of the machine room with space for an additional one when required. All the piping is designed with provision for future extension. The steam riser to each condenser is 7 in. in diameter, the water supply 3 in. in diameter, and an overflow 3½ in. in diameter, with a drop of 36 ft. to a main overflow drain which discharges into the river.

The discharge from the vertical pump is 5 in. running into an 8-in. common water main to the steam condensers. A strainer with by-pass connection is placed in this line which enlarges into a 15-in. drum having 3-in. outlets.

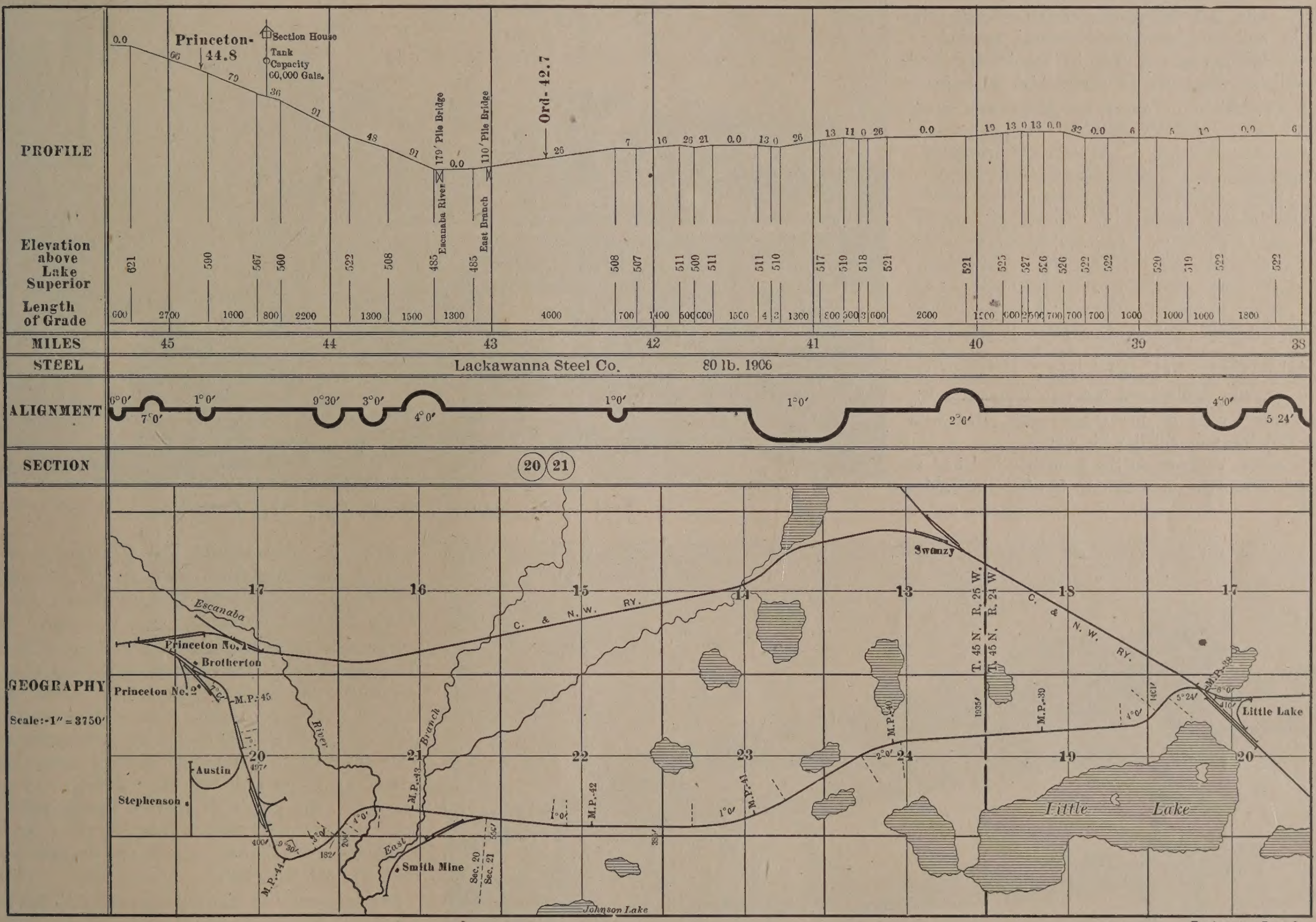
There are three gauge boards of grey polished marble, one is mounted with a Howard clock, two vacuum gauges for the steam condensers, one steam and one steam recording gauge for the supply steam. Another is provided with a brine suction, a brine discharge gauge and a recording gauge for the brine discharge. The third board is fitted with six ammonia gauges, one for each absorber, and one for each generator. There are also three steam gauges, one for each generator.

The large quantity of exhaust and low pressure steam available in the warm weather determined the choice of equipment. In the winter time when the refrigerating machine is not in commission to any extent, large amounts of low-pressure steam are required for heating the mills. In the late spring, in the summer season and early fall, when the refrigerating machines are most used, the heating requirements are small and consequently the supply of low-pressure steam is ample for the needs of refrigeration. With the selection of economical pumping units operated condensing, the amount of live steam consumed should be small. The plant has been operated long enough to substantiate this hypothesis, and has demonstrated that although it is a comparatively large plant a minimum of attention is required.

A 1,200-Volt Direct Current on an overhead trolley electric railway was inaugurated recently by the Indianapolis & Louisville Traction Co. on its line between Scottsburg and Seymour, Ind.

A Convenient Profile Chart and Map.

A chart showing the geography, profile and various other information concerning railroad location and grades has been adopted by Mr. R. C. Young, chief engineer of the Lake Superior & Ishpeming Ry., the Munising Ry., and the Marquette & Southeastern Ry. A section of this chart covering about 9 miles of a new branch of the Munising Ry. is reproduced herewith. The method of indicating the geography of the line, which is shown at the bottom of the chart, involves no special features. Just above the map, the number of the section is given and above that the alignment of the track. The weight and the manufacturer of the rails and the year the latter were laid are noted in the next line. Above that is the profile proper on which are shown the length of each grade, the elevation of different points above Lake Superior and the rate of grade in feet per mile. The location of stations, section houses, water tanks and bridges is also given accurately. This chart is made in convenient lengths on tracing cloth, so any number of blue-print copies of it may be made. It has been found of considerable value to the operating department as well as for a record of the different features of the line for the engineering department.



A Convenient Profile Chart and Map.

In this connection the method of numbering bridges which is used by these companies is worthy of notice. The accounts of the various railroads and their branches are, for convenience, distinguished in the auditing department by different letters, which are also shown on the station list on the reverse of all working time tables. These same letters are used by the engineering department in numbering bridges, the number given each bridge being the distance in miles and hundredths of a mile from the base from which measurements are made. For example, the accounts of the branch shown in the accompanying chart are carried under the letter B and a bridge on that branch 5.33 miles from its starting point would be number B5-33. With this system a bridge can always be located at once and in case a new bridge is required or an old one abandoned, the continuity of the numbering of the other bridges is not changed.

Inspection of Asphalt Pavement in the Borough of Manhattan, New York City.

A system of inspection of asphalt pavement recently introduced in the Bureau of Highways of the Borough of Manhattan, New York City, has proved so satisfactory during the few months it has been in effect that it is believed all classes of pavement in the borough will be ultimately put under the same system.

The borough, the total area of which is about 21.9 square miles, is divided into six sections of nearly equal area, each in charge of a chief inspector. Each section is subdivided into two to five divisions, each in charge of a sub-inspector. The sub-inspectors patrol the asphalt paved streets in their respective districts and make daily reports of their condition to a special office of the Bureau of Highways. The reports are in tabular form and indicate the location of every hole, its dimensions and yardage, and how made. From these reports similar lists are made out and forwarded to every contractor from whom repair work is required, showing the location of all holes in pavements of his construction that are still under contract, together with an order that same should be repaired within five days after the receipt of the notice.

The repair work is in charge of an assistant engineer, to whom the chief inspectors report in person daily. They notify him of the number of repair gangs required in their respective sections on the day following and he arranges with the contractors to supply the men.

The chief engineer of the Bureau of Highways is supplied daily with a report showing the number of repair gangs at work and the location of each. For convenience this report is indicated graphically on a wall map of the borough with pins with various colored heads, a color being reserved for each contractor.

In the special office are large-scale wall maps on which are indicated in water colors the stretches of asphalt pavement under contract, a color being reserved for each contractor as before and pins being used to mark the general location of the defects reported. When the defects are remedied the pins are removed or, if they are not repaired, a pin of a different color is substituted, so that by a glance at the map a general idea of the condition of the pavements can be obtained.

The office is able in this way to keep closely in touch with the work of the contractors and notify them promptly when repairs are necessary. Sections 1, 2 and 3 comprise the area below 59th St., and in these sections the system is in full operation. The other three sections are being organized as rapidly as possible.

The new system was devised by Mr. Henry S. Thompson, Commissioner of Public Works of the Borough of Manhattan. Mr. George W. Tillson is chief engineer of the Bureau of Highways and Mr. D. B. Goodsell, assistant engineer, is in charge of the general repairs.

Test of the Reinforced Concrete Viaduct of the Richmond & Chesapeake Bay Ry.

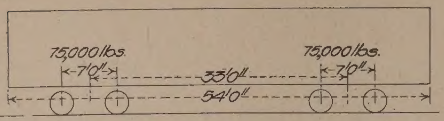
The test of the Richmond & Chesapeake Bay Ry. Co.'s reinforced concrete viaduct at Richmond, Va., a description of which structure was given in this journal on Mar. 2, 1907, will, no doubt, be of interest to users of concrete. The viaduct was designed for a train of cars each weighing 150,000 lb., with a factor of safety of four. The cars are 54-ft. long, with trucks 33-ft. apart center to center, and the wheels of the trucks on 7-ft. centers.

The specifications called for a test of twice the designed load, but as it was found practically impossible to carry out the exact prescribed test, the chief engineer devised a test load that would give practically as severe strains and a thorough test as to the strength of the structure. The accompanying sketch shows the weight and the approximate wheel spacing of the test load as agreed upon by the designer and the railway company. The gondolas were loaded with rails, spikes and bolts to their capacity, while the tender of the engine was piled with coal and the tank filled with water.

Results of Test of Viaduct of the Richmond & Chesapeake Bay Railway Co.

Span Between Bents.		Deflection of Girders.			Deflec. in Proportion to Length of Span.	
		Right.	Left.	Span.	Right.	Left.
Sledd St.	0-1	7/32"	7/32"	49' 0"	1/2688	1/2688
	1-2	.008'	.008'	23' 6"	1/2937	1/2937
	2-3	.010'	.010'	23' 6"	1/2350	1/2350
	3-4	.010'	.010'	23' 6"	1/2350	1/2350
	4-5	.011'	.009'	23' 6"	1/2136	1/2611
	5-6	.012'	.007'	23' 6"	1/1958	1/3357
	6-7	.013'	.011'	23' 6"	1/1808	1/2136
	7-8	.009'	.011'	23' 6"	1/2611	1/2136
Clay St.	68-69	3/16"	3/32"	67.4'	1/4314	1/8628
	66-67	3/32"	3/32"	33' 0"	1/4224	1/4224
	72-73	1/8"	1/8"	26' 0"	1/2496	1/2496
Marshall St.	82-83	5/32"	5/32"	67.4'	1/5176	1/5176

All of the concrete in the structure had had at least five months in which to harden and under a close inspection previous to the test, not a flaw or crack could be found which would in any way weaken the bridge. The front of the engine was attached to the cars and backed on to the structure, the tender therefore being the first to go on the bridge. The test train was first run over the bridge three times at a slow rate of speed and then accurate measurements were made for the deflection of a number of spans. The first span tested was the 49-ft. span over Sledd St. One end of these girders slide on a concrete abutment making a joint for expansion, while the other ends are built continuous with the adjoining girders. These Sledd St. girders are 54 in. deep and 20 in. wide, with a solid 3½-in. floor joining them. This span showed a ratio of deflection to total length of span of 1:2688.



Car for Which Viaduct Was Designed.

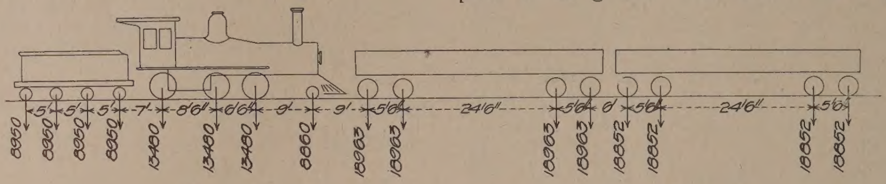
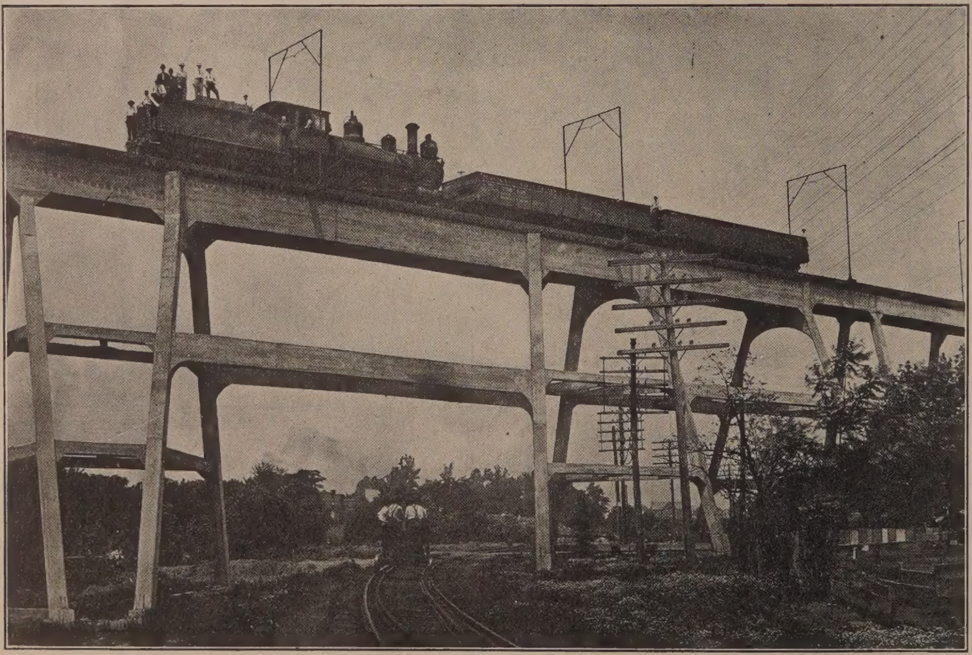


Diagram of Test Train for Reinforced Concrete Viaduct.

Test Train over Marshall Street, Span 67.4 Feet.



Test Train over Crossing of Seaboard Air Line Railway.

The deflection of this span was measured in three different ways: First, by setting a sliding rod directly under the middle of the girders and reading by the vernier of the rod the exact deflections: second, by taking a sight with an engineer's level at the rod held on the girder unloaded, and then again with the load in the position to give the greatest bending; third, by measuring with a steel tape the exact deflection from a fine mark on the girder to a solidly driven point on the ground. The three methods gave exactly the same results, and therefore it was decided in testing other spans to use only that method of ascertaining the deflections which would be most convenient.

The next spans tested were a number of 23½-ft. spans adjoining the Sledd St. span, and where, on account of the viaduct being low, it was very easy to get exact results. The girders on each side of the bridge gave exactly the same results for deflection until the curve was reached, where, on account of the super-elevation of the outer rail, the center of gravity was moved toward the western girders and, as was to be expected, they showed a trifle more deflection than the eastern ones.

Fourteen of these spans were tested and showed a ratio of deflection to total span of from 1:1808 to 1:3357. Deflections for all of these girders were so near alike it was decided that it was only necessary to test typical spans in the remainder of the bridge, as it was practically impossible to get exact results where the bridge was 50, 60 or 70-ft. high, and where there was no solid place to set a level instrument.

A typical 26-ft. span showed a ratio of deflection to span of 1:2496.

A typical 33-ft. span showed a ratio of deflection to span of 1:4224. The Marshall St. span of 67.4 ft. center to center was next tested, and the ratio of deflection to the total span was 1:5176. The Clay St. crossing with the same span of 67.4 ft. as Marshall St. resulted in the east girder deflecting 3/32 in., making a ratio of 1:8628, while the west girder deflected twice as much, with a ratio of 1:4314.

As authorities give as the permissible ratio of deflection to span 1:750, and as all of the deflections measured were so small, it was considered unnecessary to continue measuring additional spans, so it was decided to test the effect upon the bridge of the train moving at a high rate of speed, and also coming to a sudden stop by the application of the air brake. The bridge showed remarkably little vibration under this heavy load moving at a high rate of speed, and repeated tests of sudden stops made no jar in the bridge that could be noticed at all.

The test train was run over the entire bridge seven times and gave a fair test of the perfect strength and stability of the structure. The girders were perfectly elastic, returning to their original position immediately when the test load was removed. At all the spans where there were expansion joints, the deflection was greater owing to the non-continuous girders. It might be interesting to note that on very hot days the expansion is very noticeable. Although no actual measurements of the expansion have been made so far, it is safe to say that on certain days it has expanded ½ in. in 200 ft.

Since the above test of the viaduct was made the heavy suburban cars, estimated to weigh 120,000 lb. loaded, have been running back and forth continuously at a rate of speed of about 25 miles per hour. A car was suddenly stopped by the emergency brake while running at the rate of about 15 miles, but no undue vibration could be felt although the car stopped within a distance of 3 or 4 ft.

Although no deflections were taken, a rather severe test was made some days later, which was not contemplated beforehand. In order that the construction trains of the railway company might pass it was necessary to send two of the electric cars, an engine and six ballast cars loaded with ballast and also a smaller engine and a line construction car all on the bridge at one time. The vibration was no greater with this long moving load than it is with one car. After the test was over the viaduct was again closely examined. No cracks of any description appeared and the structure seemed perfect.

The Railway Statistics of the United States compiled by the Interstate Commerce Commission for the year ending June 30, 1906, have just been made public. They show that the total single-track mileage in the United States was 224,363 miles or about 6,262 miles more than at the end of the previous year. The commission received operating data from 222,340 miles. The rolling stock reported consisted of 51,672 locomotives, of which 29,848 were in freight service, 12,249 in passenger service and the remainder used for switching; 42,262 passenger cars, 1,837,914 freight cars and 78,736 cars in company service. These figures do not include cars owned by private corporations. The average number of passenger-miles per passenger locomotive was 2,055,309 and the number of ton-miles per freight locomotive was 7,232,563. There were 1,521,355 people on the pay-rolls of the railroads, equivalent to 684 employees per hundred miles of line. Of this number 59,855 were enginemen, 62,678 were firemen, 43,936 were conductors and 119,087 were other trainmen. The employees in general administrative work numbered 57,054; for maintenance of way and structures, 495,879; for maintenance of equipment, 315,952; and for conducting transportation, 649,820. The par value of the outstanding railway capital was $14,570,421,478, equivalent to $67,936 per mile. Of this amount 33.46 per cent. paid no dividends. The amount of dividends declared during the year was equivalent to 6.03 per cent. on dividend-paying stock. The average revenue per passenger-mile was 2.002 cents, and the average revenue per ton-mile was 0.748 cent. The total number of casualities during the year was 108,324, of which 10,618 were fatal. During 1906, one passenger was killed for every 2,227,041 carried and one was injured for every 74,276 carried.

Book Notes.

An excellent little trade list known as the "Directory of Portland Cement Manufacturers of the United States," has been compiled and published at $1.00, by Mr. C. Earle E. Bottomley, Land Title Building, Philadelphia. The compiler's position as secretary of the Association of American Portland Cement Manufacturers gives him the best of opportunities for obtaining accurate information regarding existing and projected companies. The statements in this directory have been corrected to Aug. 1 of the current year, and have been approved by the companies mentioned except in a very few cases. The information is arranged in the same order under the head of each company, and the notes relating to the companies are arranged alphabetically, the first company being the Aetna, and the last the York. The notes give the location of the principal office and that of the works, a list of the officers and the heads of departments, the capitalization, and the capacity of the mills.

For a good many years Mr. John K. Allen has been doing good work for sanitation through the columns of "Domestic Engineering," a trade journal which was started shortly after The Engineering Record, and has been maintained ever since as an exponent of good design and workmanship in everything relating to the heating, plumbing and lighting of buildings. During this period the sanitary fittings of a house have completely changed in their character, and what was the luxury of a few a quarter of a century ago is now the necessity of all. This is shown in a number of places in Mr. Allen's "Sanitation in the Modern Home," a small volume full of sound advice concerning the selection and drainage of a building site, the general interior arrangement from a sanitary viewpoint, the proper construction of cellar floors and walls, plumbing in the different rooms, warming by steam and hot water, furnace heating, ventilation and temperature control, lighting and other subjects. The information is well arranged and presented in such a form that anybody interested in healthy and comfortable houses can readily grasp it. (Chicago, Domestic Engineering.)

A description of works executed between 1897 and 1905 by the Mediterranean Ry. Co. has recently been issued in two sumptuously published quarto volumes profusely illustrated bearing the title "Relazione sugli Studi e Lavori Eseguiti dal 1897 al 1905." The text volume is divided into several parts, while the large atlas contains many admirable drawings and engravings. The book is mainly interesting for its account of the railroad connecting the Simplon Tunnel line with the Italian railway system. This connecting line has a number of unusual features; much of it lies through an Alpine country where the construction was extremely difficult and in places it was necessary to use helical tunnels such as were first introduced for overcoming grades on the St. Gothard R. R. The first part of the volume describes the railroads built by the company as contractor, and the second part is a collection of papers concerning their technical features, including extensive earthworks, masonry structures, iron bridges, tunnels and buildings. The last part of the book is a collection of monographs on some of the more interesting technical subjects. These include several tunnels in rock and in soft earth, the specifications for bridges prescribed by the Italian Government and other specifications for the same class of structures suggested by the company, and the geology of the region in which the work was done. The volumes form one of the most elaborate publications of an engineering nature ever issued and will be found full of valuable information concerning the construction of tunnels and railway work. (Milan, Società Italiana per le Strade Ferrate del Mediterraneo.)

Investigations of the mechanical properties of wood by the United States Forest Service are being conducted by several timber-testing stations in cooperation with the University of California, Purdue University, the University of Oregon, the University of Washington and the Yale Forest School. The general aim of these tests is to supply useful information for engineers and architects as well as to determine the value for specific purposes of quick-growing woods thus promoting the practice of conservative forest management and determining proper substitutes for material which is more valuable for uses other than those for which it is now employed. At the present time the programme of the investigation calls for tests to determine the properties of structural timber made on pieces of commercial size and grade; tests to determine the effect of the rate of application of the test loads and the effect of moisture, and tests to ascertain the influence on the properties of timber, of preservatives, methods of seasoning and fire retardants. The determination of the effect of moisture was assigned to the technical laboratory of the Yale Forest School under the general direction of Professor J. W. Toumey. The work was done by Mr. H. D. Tieman, and his report has recently been issued by the forest service under the title of "Effect of Moisture upon the Strength and Stiffness of Wood." Mr. Tiemann has determined factors by the use of which the results of tests of wood having various degrees of moisture may be reduced to a common basis in the case of certain species and certain kinds of tests. He has established the percentages of moisture at which the cell walls are saturated in the case of these species, and has determined the true nature of the law representing the effect of any further reduction of moisture on the strength of timber. His studies explain the reasons for the various facts and his subsidiary studies on case-hardening, on prolonged soaking, and on soaking followed by drying have direct application to the utilization of timber. The results apply to hardwood in small forms, such as are used in carriage building, and to softwood timber in some forms, such as crossarms for telegraph poles, where thorough and uniform drying and consequent large increase in strength may be obtained. An abridged form of the paper has also been published by the Forest Service under the title of "Strength of Wood as Influenced by Moisture," which contains the valuable reduction tables of the complete monograph.

So much depends upon proper illumination by artificial means that it is rather surprising no book on the practical features of the subject was published before Messrs. J. R. Cravath and V. R. Lansingh wrote "Practical Illumination," a work equally valuable to the technical and the non-technical reader. It is generally recognized that a large proportion of the light furnished by artificial means is wasted, while oculists are agreed that a considerable part of the deterioration of eyesight now so prevalent is due to the improper use of artificial lights. Accordingly the authors confine their discussion to the best use of light after it is produced rather than the apparatus for producing it. Most of the tests described were made in the Electrical Testing Laboratories of New York, and were thus uniform in method and character; no tests made by manufacturers have been used. Interior illumination alone has been considered, and a great many illustrations are given to show bad and good arrangements of lamps for a given purpose. The first three chapters outline the laws of light and its measurement and explain the methods of calculating the amount of illumination, thus preparing the reader to understand the methods of rating different sources of illumination adopted by the authors. Three chapters follow on individual electric, gas and acetylene burners, and their reflectors, shades and globes. The amount and dispersion of light from a naked source of illumination and their modification by reflectors and shades is a subject that few people have considered as carefully as they should, or otherwise the inefficient "decorative" shades so often seen where art alone is considered would have no sale. The number of people whose eyesight is hurt every night by attempts to reproduce the visually-destructive dinner-table candles of our forefathers must be enormous, and many have inveighed more than once against the outrages committed in the name of illumination in reading rooms and libraries. The use of clusters of incandescent lamps is becoming quite prevalent for some purposes, and a chapter is devoted to a discussion of methods of obtaining the best results from such groups. Chapters are also given on the characteristics of Nernst, electric arc, gas arc and vapor lamps, and the diagrams of the distribution of light from them give full information to those who are considering their use but are uncertain concerning the illumination they will give. Two important chapters explain the methods of making practical tests of lamps by means of demonstration rooms, and summarize the authors' views regarding the comparative uses of different illuminants. The remainder of the book describes the selection, arrangement and improvement of artificial lights for many classes of indoor service. It is illustrated by engravings showing the lighting arrangements, good and bad, in many different rooms, and will appeal directly to all who have been puzzled about the best way to light individual rooms as well as entire buildings. (New York, McGraw Publishing Co., $3.00.)

Letters to the Editor.

The Union Pacific Location.

Sir: In an editorial article entitled "The Function of Light Railways," in The Engineering Record for August 31, 1907, occurs the following statement: "Railroads have grown over the country in a sprawling, irregular fashion ever since the zig-zag war dance of the Union Pacific over its land allotments." It surprises and grieves me that such thoughtless language should be permitted to appear in a leading article of a paper conducted with the dignity and fairness which we are accustomed to find in The Engineering Record.

One infers from the quotation above cited that the editorial writer believed that the Union Pacific Railroad as originally built was located on a tortuous route, so as to make it as long as possible and thus increase its land grant, which was so many sections of land per mile of main line. Such loose talk has appeared from time to time in the speeches of cheap politicians, with an axe to grind. But it is unkind for a reputable engineering paper to publish such a gratuitous reflection on the character of the engineers who located and built the Union Pacific.

When that line was built the country through which it ran was a wilderness populated only by savage Indians. There was no traffic except as the railroad created it. It was a common saying for years after the road was opened that the receipts from the occasional trains were not enough to pay for the fuel and wheel grease used. It would have been the greatest folly to make expenditures at that time necessary to build a twentieth century trunk line. And yet what was the character of the line the Union Pacific did build in the sixties? This question is practically answered by investigating the work done during the past ten years in efforts to improve grades, alignment and distance. With practically unlimited funds to draw upon, after thorough surveys and careful examination by skilled engineers, with able contractors, a railroad in operation to deliver men and materials at any desired point, the railroad people, after years of effort and millions of expenditure, succeeded in cutting down the total length of the Union Pacific from 1033 miles to 1003 miles, less than three per cent.! Does that look like a "zig-zag war dance over land allotments?"

The original location of the Union Pacific Railroad, with which I never had anything to do, not even an acquaintance with the engineers who made it, was a piece of remarkably good engineering judgment from beginning to end, and will be so esteemed by all thoughtful engineers who may be able to investigate the facts. The Union Pacific was not built in "sprawling, irregular fashion," although financial necessity has often compelled railroads in other parts of the country, which were built in the days of small things, to adopt that sort of a location.

Respectfully, T. A.

The Quebec Bridge Collapse.

Sir:—I beg to submit a theory of the Quebec bridge disaster that accounts for every phase of the disaster so far as the facts have been made public. The theory thus far given the greatest prominence is entirely inconsistent with the facts for the following reasons. (This theory is that a bottom chord member, A9L, on the left truss in the anchor arm failed and brought down the structure.) In the first place it is unbelievable that a member of the size of the one under suspicion, with the intensity of strain it sustained, could have failed under a steady load. In the second place, initial failure of a bottom-chord member on the left truss would have thrown the whole structure to the left and not to the right as it actually fell. In the third place, initial failure in the bottom chord of the anchor arm would have thrown an enormous thrust at the foot of the tower and pushed it toward shore instead of allowing the greater part of the tower to fall riverward. In the fourth place, if the failure were the result of the continuation of the weakness observed in bottom chord member A9L, we should look for that member to fail by bowing, since it was a partial bow that was observed. In the general collapse, however, this member took an S shape.

My theory is that the traveler, which was about twice as high as the truss where it was standing, was either pulled over by accident or fell over due to insufficient cross-bracing, and that this fall to the right threw the whole top chord system to that side, crushing the vertical posts and thus causing cumulative failure of the entire superstructure. The pulling over of the erection gantry or traveler may have been done by the workmen in bracing the traveler for the night. It is customary to take the falls from one side of a traveler and attach the block to some part of the other side of the structure, then vice versa, forming X-bracing. The pulling on one such diagonal line could easily start the traveler to fall. The truss posts could not resist the fall.

The reasons I have for believing that the whole cause of failure was due to the traveler are as follows:

(1) The traveler was being dismantled, and, though 300 tons of its weight had been removed, 800 tons remained. If only 500 tons of this was in the top structure, there would be a force of about five tons at the top chord of truss for every foot that the side bents were out of plumb.

(2) The traveler had little or no lateral bracing. If it was braced, it must have been with wire ropes, which in any event, by reason of their extensibility would allow large stretch and large swaying.

(3) The vertical posts, excepting the main tower post, had little stiffness laterally to resist such a force as this traveler would produce. The single lacing was in planes normal to the truss, making the posts exceptionally weak in that direction.

(4) A blow from the traveler, such as its falling to one side would produce, would cause just such a failure as the one that occurred. It would deflect the top chord, with the sway-bracing, to one side, and the weakest part, namely, the part of the posts beside the roadway opening, would bend. This would allow the entire upper system to come down.

(5) This theory would agree with what little has been published as to the observation of men at the bridge. They say no swaying of the structure was observed. This would be expected on account of the stiffness of the lateral system at floor level. They say that the floor of the anchor arm sunk and they had to run up hill. This would be the case if the upper structure should come down: the lower chord as an arch would not stand the weight of the floor. If the lower chord failed first on one side and in one member, there would be swaying of the floor because of the unsymmetrical failure.

(6) The S shape assumed by A9L, the lower chord member that is supposed by some engineers to have been the cause of failure, fits exactly in this theory. Your account states that this S was in both members A9. The lateral thrust to the right would be communicated down the first main diagonal and the first main post in the anchor arm, at the foot of which one end of A9L was located; and this end of A9L would be pushed to the right in forming the S, just as it was found to be. This lateral push was even enough to overcome the observed bow of which so much is made and reverse half of it.

(7) The failure must have been something that affected both trusses alike otherwise the almost vertical drop is inexplicable. This would be the case with a lateral force exerted against the top chord; for as soon as the vertical posts, which were under heavy stress, would bend to one side enough to fail, everything else would give way almost at once, and every part of each truss would be affected just alike. The sway bracing between posts above the overhead struts and below the floor would hold the posts vertical in these portions until the force of the fall would crush the posts.

There is nothing mysterious about the above theory to account for the failure, and it does not carry with it the suspicion that all other large structures in which there are heavy compression members may be on the point of failure. The failure is simply brought into the class with about all other great erection failures, and is due to an omission to provide sufficient unyielding sway bracing.

Yours very truly,
Edward Godfrey.

Pittsburg, Sept. 14.

The Peat-Briquetting Plant of the Commercial Artificial Fuel Co., near Lambertville, Mich., has a capacity of 60 tons daily, the product containing 16.7 per cent. moisture, 55.3 volatile matter, 20.5 fixed carbon and 7.5 ash. Its heating value is stated to be about 10,600 B. t. u. per pound. The peat is obtained from a 10-ft. bog by a dipper dredge and taken in scows to the plant. Here it is first passed through a cutter, in which it is thoroughly disintegrated, and then through a kneading machine. It is next compressed and discharged through a die as 4x4-in. bars, which are cut by knives into briquettes 12 in. long. The latter are then dried like soft brick in sheds.